New York State Museum

JOHN M. CLARKE, Director

Bulletin 107

GEOLOGY 12

GEOLOGICAL PAPERS

Hon. A. S. Draper LL.D.
Commissioner of Education

MY DEAR SIR: I beg to communicate herewith for publication as a bulletin of the State Museum, a series of geological papers by various members of the staff of this division.

Very respectfully yours

JOHN M. CLARKE

Director

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Commissioner of Education

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POSTGLACIAL FAULTS OF EASTERN NEW YORK

BY

J. B. WOODWORTH

Introduction

While investigating the changes of level which have affected the Pleistocene river and lake deposits of the Hudson and Champlain valleys, the writer noted certain small dislocations of the bed rock which have taken place in the comparatively recent time since the glaciation of the surface. The importance of these fractures as indexes of a rock movement which appears to be associated in time at least with the tilting of the continent in the postglacial epoch led to the following study of the distribution and character of the fractures.

A reference to the literature of the State showed that Mather in the original geological survey of the first district noted the occurrence of postglacial faults on the east side of the Hudson valley. Having first referred to a class of faults much more

frequently seen in the glacial gravels, he makes the following statement in regard to the faults here referred to:

The other class is where the slate rocks on the east side of the Hudson valley had been ground down, smoothed, deeply grooved and scratched across their edges; and since the action that had produced these effects the masses of slate had been shifted a few inches in a vertical direction by a slight fault, so that the grooves and scratches on the *lower* part of the mass were continued quite up to that part that had been elevated; and on the *upper* mass, the same grooves that had been once continuous, were prolonged in their former direction, with the same breadth and depth. This shift of position, or slight fault, must have been subsequent to the period when the scratches were made, or the scratches could not have been continued close up to the vertical surface of the more elevated portion, and without wearing the sharp edge of the slate on the upper portion of the shifted mass. This locality was where the Quaternary had covered it, but the example can not with certainty be referred to that part of the Quarternary period of which we are now speaking; for it may belong to the elevation that took place after the drift period, and preceding the elevation by which the Quaternary deposits were raised to their present level.

The locality and example referred to above, was observed by myself in Copake or Ancram near the north end of Winchell's mountain, and not far from the base of Mount Washington, on the road from Copake to Boston Corners.[1] Professors Merrick and Cassels were present with me, and I called their attention to this, as an important fact for them to observe, in consequence of the kind of evidence thus afforded of the relative periods of time during which the rocks were disturbed in position. Professor Merrick, a few days afterwards, in his explorations, discovered several more localities near each other, about half a mile west of Long Pond in Clinton,[2] where the same facts were observed. I quote his report to me.

An interesting phenomenon may be seen in the rocks about $\frac{1}{2}$ mile west of Long Pond in Clinton. The parts of the rock have changed their relative position since they were worn down by the diluvial action. In two different places, at but a short distance from each other, one part of the rock has been raised, or the other part settled from 2 to 3 inches, the strata being nearly vertical. Five or six similar dislocations, of from half an inch to 1 inch, occur in the immediate vicinity.

Of the dislocation of the rocks since the effects of the diluvial action upon it, there can be no doubt, as the scratches or furrows upon the elevated and depressed parts precisely correspond, and are carried on the latter entirely up to the former, the elevated ridge of which is unmarked or broken (unbroken?). These dis-

[1] This is probably the locality described below on p. 16.   J. B. W.
[2] I have not yet seen this locality.   J. B. W.

locations are exposed for 25 or 30 feet; and it should be remarked, that they do not occur in the vicinity of a ledge, a cliff or steep hillside of rocks, or upon the side of a hill, but upon a level surface upon the summit.[1]

Mather[2] also reported another locality east of the Hudson near Hyde Park. He states that

The smoothed and scratched greywacke or grit was observed on the ridge east of Hyde Park; and about half a mile east of the post road opposite to half a mile north of De Graff's Tavern, the grooves and scratches, which were perfectly similar in size, depth and direction, were interrupted by slips or slight faults of the rock since the scratches have been made. Professor Cassels observed them in several places in that vicinity. The edges of the rock, both above and below, on the slip, were sharp, and the grooves and scratches of the lower mass were continuous plump up to the surface of the upper mass; and on the upper mass they were continued quite to the sharp edge along which the slip has taken place.

This type of relatively recent faults appears next to have been seen and described by Mr G. F. Matthew as occurring in a very pronounced manner in the environs of St John, New Brunswick. The Cambric slates of the upper division of the St John group are described by him as being cut by n. e. and s. w. faults, with a hade varying from 60° to 80° s. e. There are also diagonal faults extending north and south, and east and west. In the city of St John, the faults vary in downthrow from $\frac{1}{4}$ inch to 4 inches, the downthrow with one exception being on the north. In one locality Matthew found the sum of the displacements to be 5 feet 8 inches. He has published a photograph showing the character of the faulted surfaces.[3]

Matthew noted the reversed character of the faults and supposed the movement to be due to a failure of support beneath, or to a lateral thrust from the southeast, with his preference for the latter view, in support of which he cites the ancient mountain-building pressures acting in this direction. He also notes the pressure acting on the rocks at Monson, Mass., reported by Niles, and the occurrence of slight earthquake shocks near St John, N. B., as evidence independent of the faults that the earth's crust in this part of the continent is yielding under strain.

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[1]Mather, W. W. Geology of New York: Report on First District. 1843. p. 156–57.
[2]*Op. cit.* p. 387. Locality not visited by J. B. W.
[3]Post-glacial Faults of St John, N. B. Am. Jour. Sci. Ser. 3. 1904. 48:501–3, pl. 11. Also Movements of the Earth's Crust at St John, New Brunswick, in Post-glacial Times. N. B. Nat. Hist. Soc. Bul. 12. 1894. p. 34–42.

Another district in this geologic province in which postglacial faults have been described lies along the northern border of Vermont and New Hampshire in southwestern Quebec. Mr R. Chalmers of the Geological Survey of Canada has recently described numerous and yet more pronounced instances of these dislocations in the Cambric and Cambro-Siluric slates of that field, viz, in the southern part of the seigniory of Aubert Gallion; at St Evariste de Forsyth, Beauce county; east of Jersey Mills; near the mouth of Gilbert river, at MacLeod crossing, Canadian Pacific Railroad; east of Scotstown; between Sherbrooke and Stoke Centre, etc. Some of these localities are shown on the accompanying sketch map [pl. 1].

The prevalent downthrows are stated to be toward the north, but throws on the south or southeast occur. Chalmers reports instances of dislocations of from 4 to 6 feet. He states that the faults in this district " seem to have occurred near some ridge or mountain or mass of resisting rocks, the downthrow being usually on the side towards it, or rather the sliding up of the slates has taken place on the side farthest from it." [1]

An instance in New Hampshire noted by Professor Hitchcock is referred to in the following pages.

The above citations show that there is a group of postglacial faults found in the belts of Cambric and Lower Siluric slates over a large area with a dominant upthrow from the southeast.

Personal observations

The following notes serve to show the character of the localities cursorily described by Mather and the details of examples recently discovered. The localities which appear not to have been earlier described by others are as follows: South Troy, Rensselaer, Defreestville, and Pumpkin Hollow. The position of these places is indicated by the locality marks on the accompanying sketch map [fig. 1].

Faults in South Troy. An instructive locality of small postglacial faults was to be seen in the summer of 1904 in the southern part of Troy, on the east bank of the Hudson gorge, south of the Poesten kill. At this point the Albany clays have been largely stripped off from the basal portion of the slate wall of

[1]Chalmers, R.   Report on the Surface Geology and Auriferous Deposits of South-eastern Quebec. Geol. Sur. Can. An. Rep't. Pt J. 1898. 10:9j–12j.

Plate 1
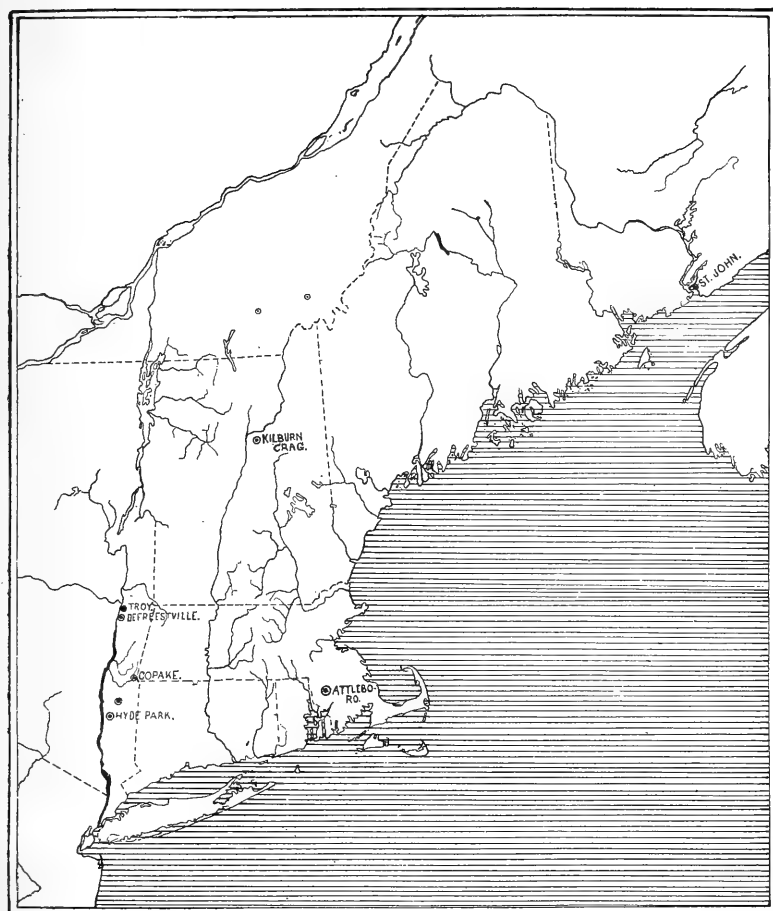
Map showing localities of postglacial faults in New York, New Brunswick and Quebec. Compiled from Mather, Matthews, Chalmers and maps by J. B. Woodworth, 1904
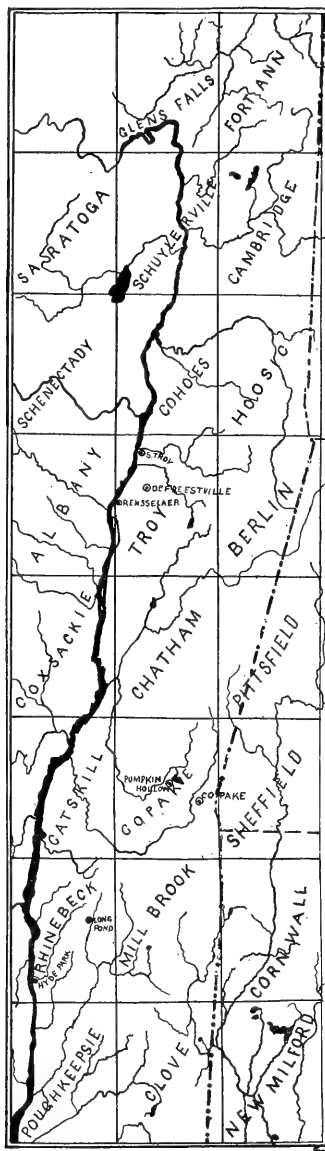
Fig. 1 Sketch map of New York east of the Hudson. The quadrangles with names correspond to the units of the State map. The localities at which postglacial faults have been seen are marked by a dotted circle.

the gorge, and a quarry has been opened north of the end of Munroe street for the purpose of obtaining the sandstone which is here caught in the axis of a complicated synclinal fold bounded

east and west by fragile black shales with a somewhat slaty structure [*see* pl. 2].

Near the base of this slope, or from about 20 to 60 feet above the level of 4th street, the surface of the rock appears in a well glaciated area broken by postglacial faults, or at least by faults which interrupt the glaciated rock surface.

The strike of the sandstones and slates is here 9° east of north, and the glacial striae run up the bank on a course s. 21° e. The dip of the slates is approximately 40° e., where not involved in the abrupt curvatures of the folds.

The faults here referred to occur, so far as my observations go, altogether on the eastern side of the sandstone beds in the axis

Fig. 2   Cross-section of the left bank of the Hudson south of the Poesten kill, in Troy, N. Y. showing position of postglacial faults in relation to river bank

of the syncline. A rough sketch of a portion of the faulted surface is shown in figure 3, in which there is no pretension to accuracy of measurement.

Below the area shown in figure 3, there is an imperfectly shown slip of 6 inches, the greatest throw I have measured in eastern New York. The faults which traverse the area mapped measured, in the order in which they are encountered in ascending the slope, 5, 1, 1.5, and from 2 to 5 inches. Thus within 30 feet measured up the slope there is a drop of 12 inches to the west on these faults. All of the faults observed at this locality are of the reverse type, with a steep dip to the east and a downthrow to the west. With one exception the faults are closely parallel to the steep dip of the stratification of the beds, though it is noticeable that there is a tendency of the fractures to depart from the bedding of the fine, black, fragile, shaly beds. One break extends practically at right angles to the bedding with an uplift on the north [*see* pl. 3]. Two of the fractures shown in the sketch converge southward and die out within the limits of the exposure. The other principal faults are traceable to the edge of the clay deposit. Their full extent in that direction is unknown.

Plate 2

Broken synclinal fold in quarry near end of Munroe street in South
Troy; looking south.   Photo by J. B. Woodworth.
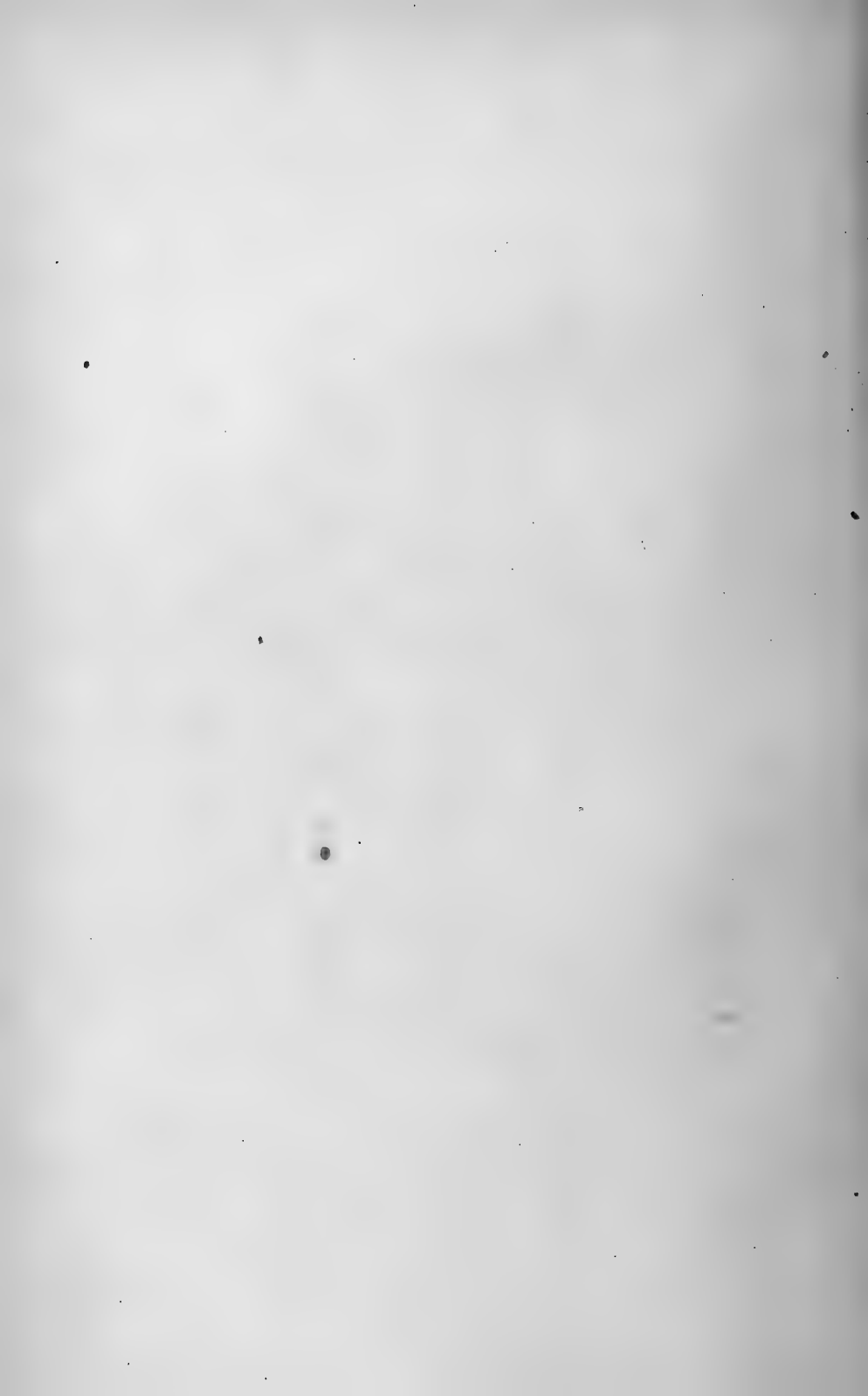
These faults appear to be limited to the fragile shales or slates lying on the eastern side of the sandstone body above mentioned.
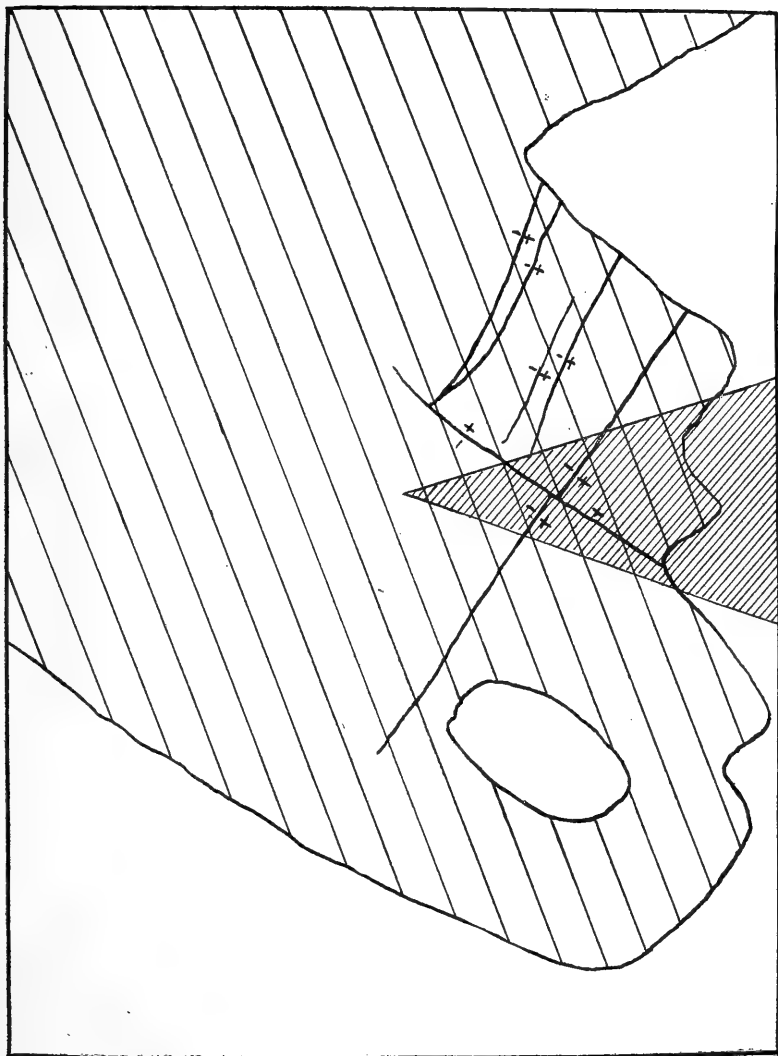
Fig. 3   Sketch map of the postglacial faults on the hillside south of the Poesten kill in Troy. The parallel oblique lines indicate the direction of the glacial striae across the exposure.   The group of heavy black lines shows the position of the faults.   Plus and minus signs stand for uplifted and downthrown sides respectively; the area left white is the clay-covered portion of the area mapped.   The triangular shaded area is that covered by the photograph in plate 3.

The folded sandstone, as shown in the photograph on plate 3 (a view looking south 15° east from a point on the shale outcrop

west of the sandstone) exhibits overthrusting to the west, evidently a movement of ancient date for there is no observable displacement at the top of the quarry just north of the Brothers' Institution. The contortion and crushing of the sandstone is either of Posthudson or Appalachian date, presumably the former. The situation of the postglacial faults along the eastern border of the sandstone core of the overturned syncline, in the plane of the reversed dip of the stratification, is precisely where overthrust planes would be expected to arise in mountain building from a continuation of the ancient pressure. If this view be correct, it is to be expected that these thrusts would find expression elsewhere in the overturned limbs of anticlines and synclines. As the folds die out north and south, so should the faults die out north and south.

In the quarry south of the Brothers' Institution in the same sandstone core at the east end of Trenton street, there were no exposures of the glaciated surface at the time of my visit and no postglacial faults were seen.

Relation of faults to landslides in Troy. Of all the cities and towns along the banks of the Hudson gorge, Troy appears to have suffered most from the slipping of the glacial and postglacial clays. These landslides are recorded in the literature of the State. Thus on March 17th, 1859, St Peter's College lost a building in process of erection by a landslip.[1]

It is a noticeable fact that many of the older brick buildings in various parts of Troy exhibit cracked and displaced walls. A cursory examination of the city made with reference to the possible occurrence of faults in the bed rock underlying the place since the construction of houses showed a considerable number of buildings upon the terrace below the eastern wall of the Hudson river gorge in which there was a fracturing of the brickwork and a drop of the western part of the building or the relative uplift of the eastern part of the house precisely in the manner in which the rock surface south of the Poesten kill has been dislocated. The following examples taken from my notes illustrate the above statement and the exceptions to it.

A foundry in South Troy shows an uplift on the western end of the building accompanied by a displacement, traceable through three stories, which has been in part repaired. This is the most noticeable movement of the kind observed.

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[1] French, J. H. Gazetteer of the State of New York. Syracuse, N. Y. 1860. p. 560, footnote.

Plate 3
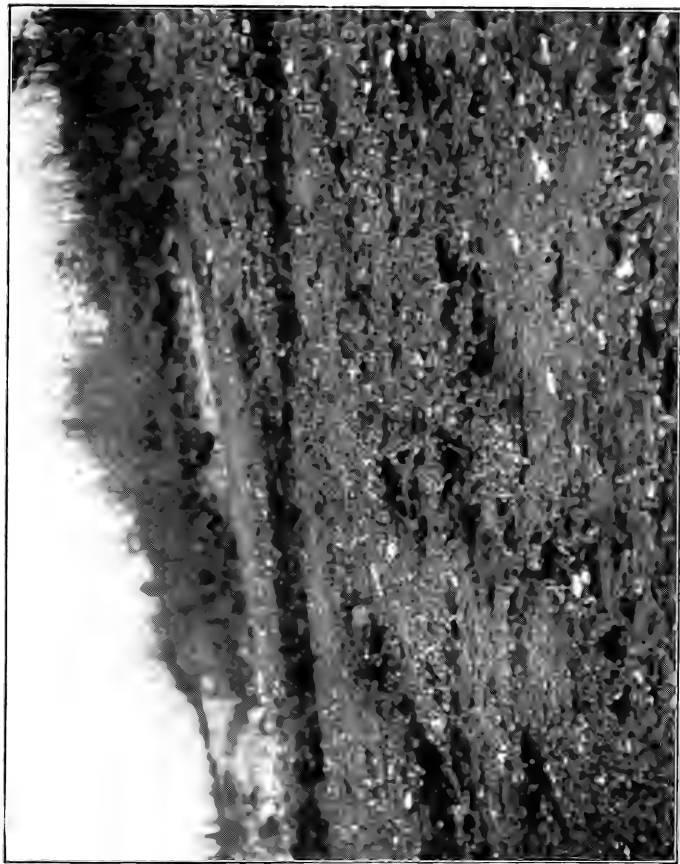
View of the intersecting faults mapped in figure 3; seen from triangular point of the shaded area

A brick shop on the south side of Washington street shows a decided drop on the west end of the building. Another building on the same street shows a settling on the west end. A brownstone sill 8 inches thick is broken.

Near the river the First Ward Free School building, a three-story brick structure, on the northeast corner of River and Liberty streets, also shows a strong crack gaping upward on the south wall near the western end of the building. The western third of the southern side appears to have been uplifted in relation to the eastern part. The corner stone according to the inscription on it was laid in 1867. Directly across the street in the north wall of an electric power station, a building erected in 1886, a crack has developed near the base in the same relative position as that in the school building but nearer the ground. A straight line from the crack in the powerhouse to that in the schoolhouse has a course n. 44° e.

The brownstone Episcopal Church on the corner of First and Liberty streets exhibits cracks in the easternmost of the upper windows on the north side of the building, but these cracks are not detected from the street on the south side of the structure. The houses opposite the church edifice on the north side of Liberty street are out of plumb and overhang slightly to the south.

The nature of the ground upon which the above mentioned structures are built is not exposed in the present condition of the streets of the city. The following observations pertain to houses resting upon the rock outcrops near the base of the sloping east wall of the gorge north of the Poesten kill. Ferry street ascends this steep hillside. Some of the older houses on this street have their foundation walls laid directly upon a level cut in the slates, the contact with which may be seen just above the sidewalk. In none of these cases was I able to discover any trace of displacement in the foundation of the house or in the leveled surface of the slates. Any considerable movement amounting to as much as even a few hundredths of an inch would, I think, have been detected. The settling and fracturing of buildings in Troy shows that a movement is taking place in the materials of the low terrace upon which the lower part of the city is built. Sometimes the eastern and at other times the western end of a building appears to have settled. Where it is known that the foundations of houses are on the bed rock no displacement has

been discovered. It is true that the faults in the bed rock are limited to narrow belts and that the houses in question may lie outside of these belts. Nevertheless, both from the reversed character of the movements in the cases of the houses which have settled and from the great amount of the movement, it seems that there is no warrant for holding that the displacements in the houses are due to the movements in the bed rock. It follows from this general conclusion that the postglacial fractures in this vicinity may be and probably are older than the settlement of Troy.

It will be observed that the postglacial fractures in the bed rock, on account of having their downthrow on the western side of the fault plane, have increased the steepness of slopes inclined to the west. On the other hand, the clays of this district in themselves constitute a mass which under certain conditions of structure and access of water are competent from their sliding movement to produce all the displacements in houses observed in Troy and vicinity.

Faults in Rensselaer. In 1900, I found small postglacial faults cutting the slates on High street near 3d avenue in Rensselaer. Within the space observed there was a downthrow of 5 inches to the west, the surface being inclined also originally in that direction. Farther south where the road going to East Greenbush ascends the east bank of the Hudson gorge, a small postglacial fault was seen on a glaciated surface overlain in the cut by till. The downthrow was to the west.

At one of the localities in this vicinity, I recollect finding an instance in which a narrow strip of slate stood up between two parallel planes of faulting. This is the only case in which in eastern New York I have observed a relative downthrow to the east.

Faults in Defreestville. It was at Defreestville in the season of 1900 that my attention first became directed to the postglacial bed rock faults. A brief note of this locality is to be found in my report on the ancient water levels of the Hudson and Champlain valleys.[1] Defreestville lies opposite Albany on the east bank of the Hudson at the inner limit of the upper clay-covered terrace and nearly on the boundary line between

[1]N. Y. State Mus. Bul. 84. 1905. p. 234-36.

the Lorraine shales and the overthrust mass of Cambric strata forming the higher ground on the east of Defreestville.

The faults are to be seen in the gutter of the road which goes southeastward from the Defreestville corners and within a quarter of a mile of the corners on the east side of the road. The slates are here vertical and the faults coincide with the cleavage planes. The slates, of grayish hue, strike n. 26° e. The glacial striae of the broken slate surface run from n. 29° e. to n. 49° e. but are mainly n. 24° e.

These faults were not measured with the closeness or accuracy later employed in the study of the fractures at Troy and Copake, but are essentially as indicated in the following table and diagram [fig. 4].

TABULATION OF FAULTS AT DEFREESTVILLE

Distance from starting point on the east	Amount of throw in inches
0	.5
6 inches..............................	1.00
12 "	4.5
8 "	.25?
24 "	4.00
18 "	1.00
24 "	.75
48 "	1.00
11.67 feet..............................	13.00 inches

Within 11.67 feet the downthrow equals 13 inches. This rate of deformation if carried out over a belt of country 1 mile wide would produce a difference of level at one end of the line as regards the other equal to 493 feet. This fault zone, however, appears to be a narrow one. The strike of the structures at Defreestville would carry this belt to the east of the exposure in Troy. The slips are close to the great fault described by Ford, Walcott, and Ruedemann in which overthrusting is exhibited at various places where the movement has been studied. According to Dale's map [U. S. Geol. Sur. Bul. 242, pl. 1] these postglacial faults would come within the area of Lower Cambric

slates on the east of the great fault. This writer makes no mention of these recent displacements in the work referred to, published in 1904. It is to be noted that the postglacial faults at Defreestville are vertical at least at the present surface of the ground, a fact which does not preclude their belonging to the class of reverse faults due to compression.

Faults at Copake. The fractures in Copake are to be seen at the road corners ¾ mile south of the Central New England Railroad station. Altogether the exposures of the phenomena at this locality constitute the most instructive assemblage of these small fractures which the writer has seen. It is stated above that this is probably the locality originally found by Mather. The slates, lying within the area mapped as Cambro-Siluric
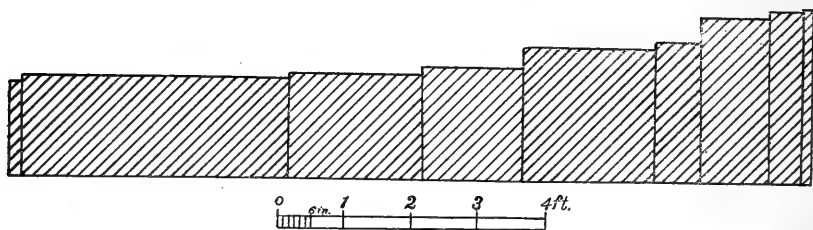
Fig. 4   A cross-section of the postglacial faults in the vertical slates at Defreestville, N. Y. The slight westward inclination of the road is neglected in the profile.   The fourth fault from the right is assumed to be .25 inches throw in the table.   The oblique lines in the diagram stand for shading only.

limestone on the State map of 1901, are exposed along the eastern side of the main road from Copake to Boston Corners for several yards north of the crossroads and as well on the west side of the main road in the crossroad.

The following very detailed measurements were made at this locality with the view of determining precisely the rate of displacement for a given horizontal distance, for in this way only can the throw for the belt of fracture be determined. The first measurement was made from right to left across the area north of the crossroads shown in the photograph [pl. 4]. A tape measure divided into feet, inches and quarter inches was laid over the surface of the road at right angles to the structure with the zero end of the tape on the east in each case. The surface of the rock inclined very gently to the west but no allowance has been made in the distance for this departure from horizontality.

Plate 4

Postglacial faults ¾ mile south of Copake Railroad station. Looking north by east. Photo by J. B. Woodworth

TABLE I   EXPOSURE, JUST NORTH OF THE CROSSROADS, ON MAIN ROAD

Distance from o Feet Inches		Westward downthrow in inches
	2.	.50
I	0.	.54
3	2.	1.70
3	7.	.04
4	0.75	.06
4	2.75	.18
4	10.	.62
5	5.75	.15
6	.0.	1.00
7	2.	.62
7	9.	.09
8	7.	.80
11	10.	1.37

Total throw for 11 feet 10 inches...........   7.67 inches

West of the main road near the southwest corner of the cross-
roads within the area of the west road [see pl. 5] another series
of faults lying to the west of those in table 1 was measured,
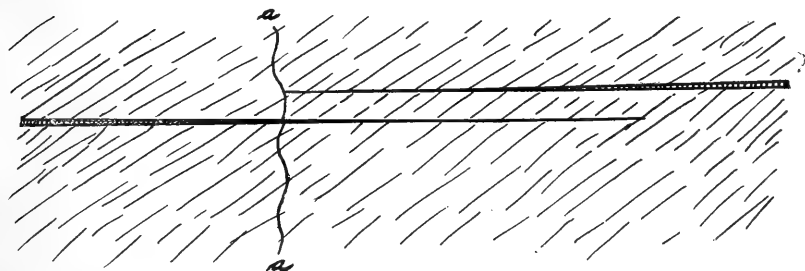
Fig. 5   Sketch of two small postglacial faults, overlapping and dying out; a, a, a ragged
joint transverse to the structure

pains being taken to determine that the rocks and the fractures
did not overlap into continuity with those in the first set.   There
is a covered space in the main road between the two sections so
that precise measurements of faults which might exist in this
interval were not attainable; but the zero point of table 2 is so
close to the strike of the western end of the section in table 1
that few faults can intervene between the two tables.

TABLE 2   EXPOSURE, WEST OF THE CROSSROADS IN THE WEST ROAD

Distance from o Feet Inches	Westward downthrow in inches
6.	.24
8.	.06
9.25	.14
11.	.14
1 1.	.10
1 6.	.15
1 7.5	.10
2 1.25	.12
2 5.5	.18
2 10.	.04
3 4.25	1.17
4 6.5	.02
4 9.	1.32
5 0.75	.12
5 5.	.13
6 0.2	.42
6 9.5	.30
8 6.5	.55
8 9.	.10
9 1.25	.10
9 2.5	.12
9 5.5	.10
9 7.	.08
9 10.25	.08
10 0.75	.10
10 1.	.01
10 3.	.10
10 5.25	.10
10 9.5	.38
11 1.5	.14
11 4.5	.10
11 6.5	.15

11 feet 6.5 inches downthrow equals.......   7.21 inches

For 41 feet west of the end of the above measured section the surface of the slates is exposed, showing at least seven small faults varying from half an inch to 1 inch downthrow to the west. There are also numberless smaller faults as in table 2;

Plate 5
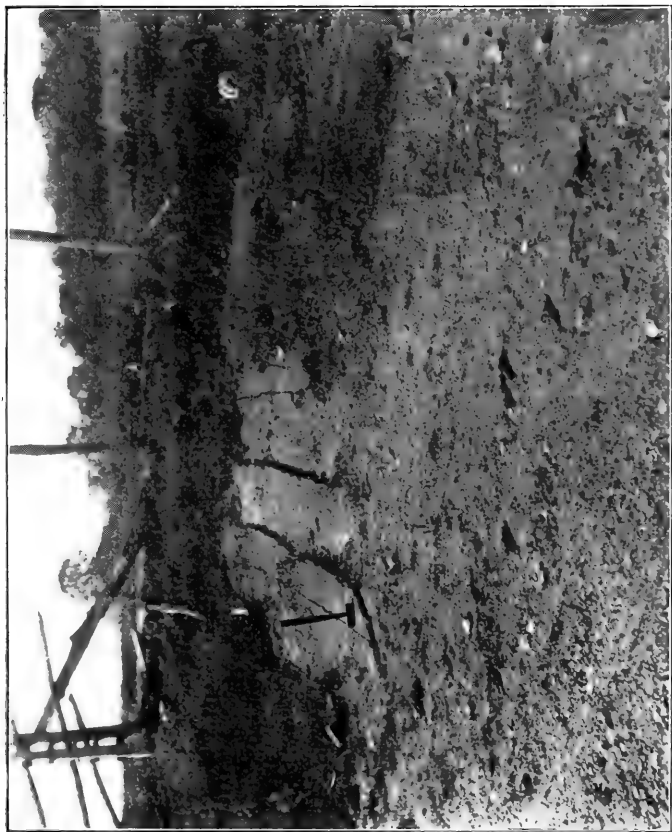
Postglacial faults $\frac{3}{4}$ mile south of Copake railroad station; west of main
road; looking south.   Photo by J. B. Woodworth

but the roadway has been much worn and weathered and precise measurements are unattainable and were not attempted.

The two tables show a closely similar rate of dislocation for a given distance within the belt. Thus in the first case there is a displacement of 7.67 inches in a distance of 11 feet, 10 inches, and in the second case a displacement of 7.21 inches in a distance of 11 feet, 6 inches, an average of 7.44 inches in a distance of 11 feet, 8 inches, nearly 1.9 inches a yard, or 336.7 feet a mile.

The apparent uplift on the east at this locality, basing the estimate upon the two measured portions of the sections and upon that which was estimated only amounts to nearly 2 feet within little more than the width of the highway. If allowance is made for the very minute fractures revealed by a close examination of the glaciated surface with a pocket lens, it seems a conservative estimate to state that the dislocation at this locality exceeds 2 feet of vertical displacement.

The faults at this locality lie with rare exceptions in the cleavage planes whose strike is n. 30° e. and whose dip is 60° e. The glacial striae run n. 10° w.

At a point on the roadside where the slates have been cut away in grading the road, chance was given to observe the appearance of the cleavage faces for a foot or more below the surface along the plane of a fault. Although the vertical movement on this plane was less than an inch, well formed vertical slickensides were found. The surface of the slickensides was dull and water stained without that polishing which is characteristic of faults along which movement has recently taken place.

Near the northern end of the exposure on the east side of the road two small parallel faults were seen overlapping [see fig. 5], one dying out southward, the other northward, as in the accompanying figure. At another point at this locality a fracture cuts the slaty cleavage obliquely, but the downthrow is here, as elsewhere in this vicinity, on the west.

Fractures near Pumpkin Hollow. Three fourths of a mile northwest of Pumpkin Hollow, at a point about a mile west of Copake Lake in the town of Taghkanic, postglacial fractures occur in slates on the western slope of a hill. The glaciated surface was at the time of my visit exposed in small areas of outcrop. Within a distance of 200 feet up the slope I made a rough measurement of 17 inches of displacement by small faults, varying in individual cases from a quarter of an inch up to nearly 3

inches of throw. The larger faults are from 1 to 3 feet apart. The downthrow in each case is to the west. The slates, in some outcrops phyllitic, dip east at an angle of about 60°, and strike n. e. and s. w.

The tectonic structure of the rocks in this vicinity is not ascertainable from local observations. At the base of the hill on the west of the public road there is a large nest of white vein quartz in the slates which may or may not have been a factor in resisting and localizing the effects of the thrust which produced the faults.

South of this locality in the road corners at Pumpkin Hollow, a postglacial fault with a throw of .75 inch was observed in blue, crumpled slates.

Two and a half miles southeast of Taghkanic village along the road to Chrysler pond, on the hillside south of the road and near the eastern end of a swamp in the east-west depression which exists there, one postglacial break of about an inch with a downthrow on the west was found in a rather resistant rock shot through with quartz veins.

When one considers the smallness of the exposures which are available for observations—most of the rock remaining covered with drift or soil and many of the exposures being deeply weathered—it must be admitted that the slate belt through Copake and Taghkanic is extensively broken by small postglacial faults. Owing to the eastward dip of the slates, exposures are naturally more abundantly observed on the western than on the eastern slopes of the hills throughout this region. The failure to find these fractures on the eastern slopes, where indeed many exposures also occur, is perhaps explained by the fact that the little steps produced by the faults serve to catch and hold the soil from slipping and thus to prevent exposures.

The rocks of this belt are mapped as " Metamorphosed Hudson " on the geologic map of New York published in 1901.

General remarks on Hudson river area

In the season of 1904 a reconnaissance was made of the district from Glens Falls southward on both sides of the Hudson river. All the certain and measurable faults of this character so far found have been described in the above account. It will be observed that the phenomena are apparently restricted to the east side of the river along the western base of the Taconic-

Green mountain belt in a region of folded, faulted, and over-thrust slates ranging in age from the Lower Cambric to the summit of the Lower Siluric. Many outcrops were found in which postglacial faulting is to be suspected, as in the case of the soft black slates in Argyle, but the weathering away of the original glaciated surface has removed the evidence upon which the proof of the movement depends. Over a large part of the rounded slate hills of Argyle, the glacial drift has been entirely removed, evidently by currents of water marginal to the receding ice sheet, so that weathering has had a deep effect upon these fragile slates.

A peculiar distribution of outcrops of slate on certain hillsides along the southern border of the Fort Ann quadrangle is in accordance with the local *en echelon* distribution of many faults, but this rhythmic succession of small cliffs in groups on the hillsides may be due to the manner of the glacial erosion, the uplifted side or top of the small cliffs having the appearance of an imperfect *roche moutonnée* the lower side of which has been plucked away. These cliffs form an advancing and receding, ascending and descending, series of exposures, the distribution of which is analogous to that of the small cliffs produced by the spacing of such faults as are shown in figure 5 of this paper. This class of outcrop forms deserves further investigation from several points of view and they can not be said at present to be the result of faulting.

From Fort Edward down the Hudson river as far as Troy no postglacial faults of an undoubted character were found. In the rock cut for the electric railway near the mouth of the Moses kill between Fort Edward and Schuylerville, the slates exhibit bright and shining slickensides near the present surface of the ground attesting to slight movements along gliding planes within the zone to which weathering has ordinarily penetrated and blemished polished surfaces that have not been kept bright by secular or spasmodic recent motion.

Judging from such occurrences as have so far come to light in eastern New York, these postglacial faults occur sporadically, dying out north and south along the strike of the Cambric and Lower Siluric slate belt. From the observed relations to the axes of folds at Troy, the movement in the slates appears to be clearly one of overthrust in a region of already overturned and faulted anticlines and synclines, an overthrust acting in the same

direction as the ancient mountain-building pressures which produced the eastward dipping cleavage. If the case at Troy be taken as a clew, the faults might be expected, as pointed out above, to occur most abundantly and most pronouncedly on the overturned flanks of the synclinal axes in the zone of strain in which an overthrust normally begins in folded strata.

From the data so far at hand it can not be assumed that the measured rates of dislocation within any given horizontal distance of exposure continue beneath the drift-covered portions of the field, and consequently the attempt to determine the relative uplift of the surface at the base of the mountains, as compared with the level at the shore of the Hudson, must give an uncertain, probably minimum, measure which will vary also in amount from north to south along the extension of the phenomenon. Even this possible difference of level between the eastern and western limits of the faulted zone may be only apparent, the faulting being effected by a rotational movement of the slices of rock between the fault planes. A steepening of the high eastward dip of the cleavage would produce the observed local result without changing the attitude of the surface as a whole.

The exposures in eastern New York are so near tide level and bench marks accurately determined that it would appear desirable to make precise determinations of the level of certain points along the eastern and western limits of the zone of faulting with the view of comparing the measurements with a second series of observations made after some lapse of time for the purpose of ascertaining the nature of the movement if it is still in progress. For the same reason observations might be made at particularly favorable sites where the faults are well exposed through some such means as the perhaps too delicate bifilar pendulum affords so as to obtain within a few days an indication of the tilting if it is going on at the present time.

There are no observations as to the depth to which the faults affect the slates. I am not aware that the faulted belt is one peculiarly liable to earthquake shocks at the present time.

In conclusion, it may be stated that the postglacial faults appear to lie in a zone of overthrusting extending along the western base of the Taconic and Green mountain uplift of folded structures from near the Highlands of the Hudson into the province of Quebec, with at present notable gaps in the obser-

vations. A like zone of displacement parallel in direction but far to the east is found in southeastern New Brunswick. While the observed small fault scarps are postglacial in origin, it can not be said that the faulting is wholly of postglacial date; secular preglacial and interglacial faulting along the same zones would have had the evidence effaced by glacial erosion. Observations have not so far determined whether the movement is in progress or not.

When we compare these structures on the east of the Hudson in the vicinity of Troy with the faulted structures on the west in the vicinity of Little Falls on the southern border of the Adirondacks, the upper Hudson valley assumes the appearance of a broad graben, bounded by normal faults on the west and overthrusts on the east, an unsymmetrical structure in which the rock movements of unlike character are probably also of dissimilar age.

Evidence of dislocation in northern New York and Quebec

Evidence of faulting which appears to be of recent date, though not definitely determined to be postglacial as in the case of the interrupted glaciated surfaces, was observed by the writer at a number of points on the north, of which the two most striking instances were seen on Trembleau mountain, at Port Kent, N. Y., and on Mt St John (or Monnoir) near St Gregoire in the province of Quebec.

Probable fault on Trembleau mountain. Trembleau mountain is a mass of norite projecting into Lake Champlain at Port Kent. The eastern slope of this mass is benched more or less definitely at an elevation of about 100 feet above the lake. Approaching the foot of the hill from the pasture southwest of the railroad station at Port Kent, on the level of the old delta of the Ausable river, the rocky bluff is most easily ascended at a point where the rock is broken down and a shallow gully encumbered with blocks of local derivation leads up to the platform mentioned. This depression is traceable southward over the top of the bench along the line where otherwise its surface would join the steeper slope of the mass in its rear. The rocks are massive, and faulting is consequently difficult to prove; but the slopes are interrupted with an apparent uplift of the bench on the east, and the zone of displacement, a few feet wide, forms a trench in which large angular blocks have come to rest. This

part of the slope of the mountain was wave washed during the late marine invasion of the Champlain valley. I could not determine that the delta surface immediately north of this locality exhibited a trace of dislocation attributable to the postglacial origin and continuation of this supposed fault into the rocks underlying the delta.

Probable fault on Mt St John, Quebec. Mt St John is the small conical elevation of basic igneous rock seen standing up on the plains between northern Vermont and the St Lawrence river. Viewed from the train on the Intercolonial Railway between Chambly and Beloeil, St John presents an outline on its northern aspect like that shown in the appended sketch, figure 6. On ascending the mountain as high as the quarries
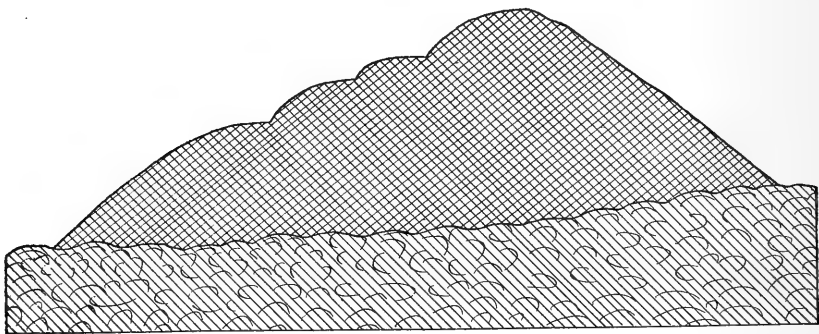

Fig. 6   Outline of Mt St John (Monnoir) viewed from the north. The lower part of the sketch is meant to show the top of the forest.

worked on its eastern face near the summit, it is found that the steps shown in the above view are separated from the slope back of them by evidences of fracture, and in one case, I believe, also of dislocation. The most pronounced fissure which I examined at the level of the highest quarry showed a gap partly filled with large blocks which had tumbled in from the sides and the slope of the mountain above the bench. The fissure opens at the surface much above the level to which, according to my determinations, the sea extended in the postglacial marine invasion; moreover, the chasm is not of the wave-made type. When the sea makes a chasm it removes in so doing the blocks of rock in and about it or above the level of the chasm floor. The annexed sketch, which below the surface line is partly conjectural, gives at least the superficial aspects of the locality as I saw them.

Postglacial faults in New England

Two instances at least of these movements are now known.

Postglacial faults at Attleboro, Mass. Postglacial faults of the class described in this paper are now known to exist in southern Massachusetts. In April 1905 I found them well developed in vertical Carboniferous sandstones and shales without slaty cleavage on the south side of the axis of the Attleboro syncline at a locality a little over a mile southwest of Attleboro, Mass. The outcrops are near the point where the Thatcher road bridge spans the railroad from Boston to Providence. The principal ledge is illustrated in a report on the geology of the
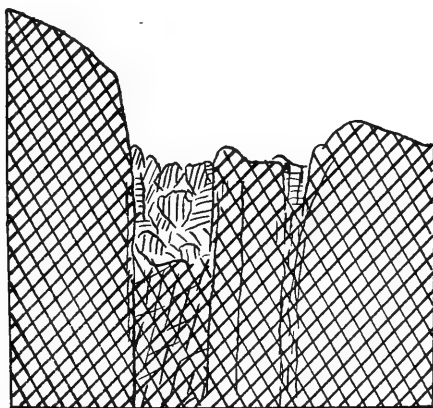

Fig. 7   Diagrammatic cross-section of supposed fissure near the top of Mt St John, looking west by north

Narragansett basin,[1] but these faults were not particularly noted at the time the field work was done. At the outcrop near the railroad track I measured a downthrow to the south of 3 inches distributed over five small faults. The largest throw measured was 1.07 inches and the smallest measured was .24 inches. These were widely distributed over a space nearly 100 feet wide measured across the strike of the beds. The faults occur in the plane of the bedding. The strike of the beds at this locality is n. 52° e. The rock surfaces are usually well glaciated and the detection of postglacial slips is accordingly readily made. In an outcrop in the field near by there is an apparent downthrow of 1 foot to the north but weathering has somewhat obscured the evidence.

[1]*See* U. S. Geol. Sur. Monograph 33.   1899.   pl. 7, p. 175–76.

In the old quarry on Ides hill ancient faults are well marked by slickensides in the bedding planes showing that this movement is by no means a recent one.

Postglacial faults in New Hampshire. Prof. C. H. Hitchcock reports a case of postglacial faults in slates on the summit of Kilburn's Crag, near Littleton, N. H.[1] He states that "segments of the slate have been crowded up (or down) a quarter of an inch since the glaciation was effected. When made the smoothing must have been continuous; now one part of the ledge, with the striae upon it, is a quarter of an inch higher than what is adjacent, and the change is abrupt. These jogs in the ledge are small faults made by the same crowding from one side that has lifted up the mountains." He supposes such cracks to have been accompanied by earthquake shocks, intimating that the total movement took place at one time.

In a letter to the writer dated June 19, 1905, Professor Hitchcock states that as he recalls the faults at Kilburn Crag their course is nearly east and west and the downthrow on the south side.

General conclusion

The detailed observations given in this paper, slight and incomplete as they are, show that the change of level or the so called tilting of the land in and about the New England district since the retreat of the Wisconsin ice sheet has been accompanied by the fracturing of rocks in certain zones of structure presumably so disposed as to yield to stress by small repetitive faults mainly with a downthrow to the northwest in structures whose strike is northeast and southwest, and with a downthrow mainly to the south in structures whose strike is nearly east and west. While the throws as pointed out appear from the reports to be on the whole greater along the northern borders of New England in the field described by Matthew and Chalmers than on the south in New York and while at the same time the examples from the interior of New England so far reported also favor the view of uplift on the north and downthrow on the south, the examples so far known are too few to warrant drawing the conclusion from them that the degree of faulting is commensurate with the extent of the tilting and change of level. Wherever we have full evidence of the nature of the faults they appear to

[1]"The Geology of Littleton, New Hampshire," reprinted from *History of Littleton*, 1905, p. 28–29.

be of the reverse type, indicating compression. The direction of
the throw must depend upon the attitude of the planes of struc-
ture—stratification or cleavage, or both—along which the move-
ment takes place. In stratified rocks which have been thrown
into anticlines and synclines, and have been subsequently
rather deeply base-leveled, it is probable that the continuance
of the lateral pressure which gave rise to the folds would con-
centrate the horizontal strain upon the cores of the synclines in
such a manner as to cause successive boat-shaped layers of
rock with their wedge-shaped cross-sections to rise upward. By
reason of the inward dip of the strata about the synclinal axes
the appearance of overthrust would appear in the slips which
marked the movement, as shown in the accompanying theoreti-
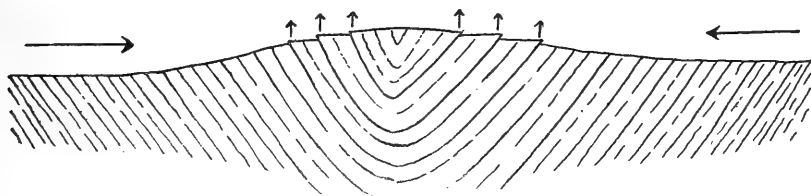cal diagram [fig. 8]. Thus synclinal cores must have a tend-

Fig. 8   Diagram showing cross-section of a normal upright syncline with a rising core due to
slipping of successive layers in the trough under lateral compression

ency independently of resistant remnant beds in their troughs
to stand above the general level or to give rise to upfolds in the
horizontal newer strata which in certain districts lie unconform-
ably upon them. Small faults of this nature may arise in folded
strata without direct connection with those greater and more
deep seated faults which appear so abundantly in eastern North
America to have had their origin in the fracture and displace-
ment of the crystalline Precambric terrane. It is worthy of
note that the few instances of postglacial faults as yet reported
appear to be everywhere associated with highly inclined strata.
It is to be presumed that the same stresses are equally opera-
tive in the regions of horizontal strata with consequent displace-
ments which take the form of horizontal thrust-planes whose
time of movement is not so readily determined.

The bearing of these observations and inferences upon the
ancient water levels of the Hudson valley in the present state of
our knowledge would seem to indicate that the shore lines of
the eastern side of the Hudson gorge north of the Highlands

are somewhat higher than the equivalent shore lines of the western side. It is not clear however that the amount of this difference is definable. In the vicinity of Troy it is greater than 1 foot—how much greater can not at present be stated. If the shore lines on the sides of the Hudson valley in that latitude were features whose elevation could be exactly measured, a precise leveling would undoubtedly afford a fairly accurate measure of the deformation on an east and west line due to this cause since the formation of the ancient marks of the highest stand of the water.

It is to be hoped that the numerous examples of these postglacial movements which undoubtedly are to be found in the numerous exposures of the bed rock in and about New England will shortly furnish data for a concise statement of the extent to which the warping of the crust has taken place in this manner and that further studies will afford evidence concerning the nature of the movements as to whether they are secular or spasmodic.

STRATIGRAPHIC RELATIONS OF THE ONEIDA CONGLOMERATE

BY

C. A. HARTNAGEL

The Oneida conglomerate is a formation which has long been known in New York geology. Occupying as it does, in sections where it is best known, a position directly above the Lorraine shale, and being composed of coarse pebbles, it has always been easy to recognize.

This conglomerate was early described by Emmons[1] under the name of " millstone grit," and the stratigraphic position assigned to it by him was above the " graywacke," or " metalliferous graywacke," and below the " saliferous rock." The former corresponds to the Lorraine shale and the latter to what is currently known as the Medina, though the " saliferous rock " was in many cases, as an examination of his text shows, confused with the Vernon red shales of the Salina, and in Herkimer county with the Clinton, since in the latter locality the gray band of the Medina is correlated with the upper Clinton sandstone.[2]

Outcrops of the conglomerate were noted by Emmons from Steele's creek near Ilion and westward at several localities to the south of Utica, and from here west as far as 3 miles south of Rome. Another locality [p. 35] mentioned by Emmons is at the lower Genesee falls at Rochester. This statement, however, is clearly an error, as this locality is again mentioned for the " gray band " which Emmons placed above the Medina or " saliferous rock." That Emmons did not intend to include the " millstone grit " in the rock series at the above locality is shown by his statement on page 96 where he says, " There (Rochester) the red saliferous rock being the lowest in view, this (the millstone grit) is undoubtedly concealed below it." The result of the observations of Emmons as shown by his text and the plate accompanying was that the Oneida conglomerate occupied a position below the red Medina and that the conglomerate extended as a concealed formation westward beyond the limits of the State.

[1]Geological and Agricultural Survey of the District adjoining Erie Canal. 1824. p. 35, 95–102
[2]See Vanuxem. Assembly Doc. 1838. No. 200. p. 268.

The first geologist assigned to the third geological district of the State was T. A. Conrad. The district included the area of the Oneida conglomerate. Conrad describes the members of the Siluric under the general heading, " Sandstone series or second division." The lowest member described is the " gray sandstone and shales of Salmon river "[1] (=Oswego sandstone). Under this chapter Conrad states [p. 168]: " Near Clinton, in Oneida county, there is a silicious conglomerate, dipping at an angle of 10° to s. w., which is either a portion of this formation or of the next above it, but time has not yet been given to the investigation of its true relative position." Above the shales of the Salmon river, Conrad places the red or variegated sandstone of the Niagara river. The latter is the " saliferous rock " of Eaton as described from western New York, to which the term Medina is now applied. Under the " Mineral character," etc., of the red sandstone, Conrad states [p. 172]: "At the falls of Oswego the red sandstone is abundant, of a coarse texture, and does not appear to be much used at present. Lines of cleavage oblique to the plane of stratification, are here very obvious. The upper layers consist of a coarse conglomerate or pudding stone. The sandstone near the top of the series alternates with red shale, both containing F u c o i d e s a l l e g h a n i e n s i s , the shale seeming to be a mass of them cemented by argillaceous and ferruginous earths." [p. 173]

The work of Conrad as geologist of the third district terminated with his appointment as first State Paleontologist and Vanuxem was assigned to his place as geologist of the new third district.

In the annual report for 1838 the Oneida conglomerate is described by Vanuxem as follows [p. 267]:

Millstone grit of Professor Eaton.—Immediately on the green shale [Lorraine], without any connection other than support, reposes this quartz conglomerate, a rock of some interest, being the first one met with made up of rolled stones or pebbles. They are of vitreous quartz. This rock extends throughout Herkimer and Oneida, with a thickness of 30 or more feet. . . The lower part of the conglomerate is almost invariably highly charged with sulphuret of iron or pyrites, the part containing it usually from 5 to 6 inches in thickness. . . Resting on the millstone grit, a series of shales and sandstones are discovered, extremely diversified in composition, color, thickness, contents or associates, meriting the name protean mass [=Clinton]. This is the saliferous rock of Professor Eaton, including the gray band. . . [p. 273] The northern edge of the millstone grit

Plate 1

Contact between the Frankfort (Lorraine) shale and the Oneida conglomerate. Moyer creek, 3 miles southwest from Frankfort, Herkimer co.

corresponds very nearly with a line extending through the villages of New Hartford and Vernon Center.   It shows itself in the water courses to the east of Utica, near New Hartford in many places, south of Hampton village, also at Oneida Springs, and the stone pound near Stony creek to the north and west of Verona.   .   .   It presents likewise a few of the large imperfect fucoides, and no other fossil.   .   .   In a practical point of view this rock in Oneida county forms an important line of division in the description of the rocks which occur to the north and the south of it, dipping as the rocks do to the south and west. .   .   [p. 282]   In no part of Oswego (county) were we able to discover the millstone grit as a solid rock or mass.   We had reason to believe that it had existed near Cleveland [on Oneida lake], from the prodigious number of large fragments or blocks which are found to the east of the village, on the high bank and in the bank and on the shore of the lake, as well, likewise, about a half mile from that place to the east, on the road to Rome.

In the summary of this report, Vanuxem states [p. 284]:

" Millstone grit "—All the preceding rocks are below this mass, all passing under it.   This rock is the first mass of pebbles met with in the series.   The pebbles are of glassy quartz, same as those met with in the Calciferous, only more waterworn. Nothing extraneous in this rock, but pyrites and a few large imperfect fucoides.

North of Wood creek and Oneida lake, the green [=Oswego] and red sandstone [=Medina] follow the last described series [=Lorraine], but south of the Mohawk, the grit follows that series [=Lorraine] and upon the grit reposes the protean [=Clinton] group.   The gray and red sandstone, within the limits examined, presenting no well defined common character of union with the protean group, requires more extended observation west, to remove the ambiguity occasioned by the absence of the grit in Oswego [county].

In the report as above given, Vanuxem extended his observations farther west than his predecessors and examined the Oneida at its type section.   It is clear, however, from the above, that he regarded the Oneida as above the red Medina shales which follow the Oswego sandstone.

In the annual report for 1839, page 242, Vanuxem states what he considers to be the proper correlation westward of the Oneida, as follows:

The " millstone grit," which is 30 and more feet in thickness in Herkimer and Oneida, gradually attenuates in going westward, being from 4 to 5 feet at Rochester.   The materials of which this rock is formed, gravel and sand, prove that their source was easterly.   In Herkimer and in the eastern part of Oneida, the pebbles are larger and the mass thicker, the sand increasing going west, whilst the pebbles diminish in the same direction.   Thus, in Cayuga the pebbles are rare, and I know

not that they have been noticed in the " gray band " at Rochester, the continuation or equivalent of the " millstone grit."

In the report for 1840, page 373, the succession of rocks as given by Vanuxem is as follows:

1 Protean group.
2 Oneida conglomerate.
3 Medina sandstone.
4 Salmon river sandstone.   (=Oswego sandstone).
5 Pulaski shales   } (=Lorraine).
6 Frankfort slate   }

In the above report, the term Oneida conglomerate is used for the first time and as defined it is the equivalent of the " millstone grit " of Professor Eaton. This is also the last of the annual reports in which Vanuxem considers the conglomerate. A detailed account is given in the final report comprising the geology of the third district, to which reference will be made later.

While Vanuxem was carrying on his investigation in the third district, Hall was carrying on similar work in the fourth district, comprising the western portion of the State.

In the annual report of the fourth district for 1838, page 294, Hall states, in referring to the Medina sandstone: " The upper stratum of this rock has been called ' grayband,' by Professor Eaton; it, however, appears to be only a gray stratum of the sandstone, generally more silicious and indestructible than the rock below."

In the same report, in describing the Medina in the town of Wolcott, he states [p. 325]: " The upper layers are hard, silicious and occasionally pass into a conglomerate or pudding stone."

With the publication of the final report on the geology of the third district in 1842, Vanuxem concluded his investigations as a member of the State survey. In this volume, under the descriptions of the formations and in the geology of the counties in which the Oneida was known, is contained an extensive account of the Oneida conglomerate. The succession in descending order as given by Vanuxem in his final report follows:

Ontario
division
{
1 Niagara group.
2 Clinton group.
3 Oneida conglomerate.
4 Medina sandstone.
5 Gray sandstone of Oswego.
}
6 Hudson River group.

As synonyms for the Oneida conglomerate, Vanuxem gives the following: " Shawangunk conglomerate," " millstone grit

Plate 2

Cross-bedding in Upper Medina sandstone. South branch of Moyer creek, 200 yards above and about 110 feet higher than the conglomerate shown in plate 1. This horizon is approximately that of the "gray band" of the Medina as known in western New York

of Eaton," " gray band of Rochester "; being a sandstone to the west, and a conglomerate and sandstone to the east.

In the final report of the district geologists, Vanuxem alone defined the Ontaric system as above stated. Hall and Emmons included the Oneida conglomerate as the highest member of the Champlainic system and the Medina sandstone as the lowest member of the Ontaric or Upper Siluric. Mather, however, was more in harmony with Vanuxem and the Shawangunk conglomerate [p. 2] alone was included in the Ontaric system. However, the other members present above the conglomerate were referred to by Mather as the [p. 353] " pyritous strata and red shales and grit." In his report [p. 2] this conglomerate is designated the " Oneida or Shawangunk conglomerate."

In a " Review of the New York Geological Reports," contained in the *American Journal of Science* [Ser. 1. 1844. 47:354], the writer of the article follows Emmons and Hall and includes the Oswego sandstone and Oneida conglomerate in the Champlainic division and the Medina sandstone is made the base of the Ontaric.

In publications following the final reports of the district geologists, the Oneida gradually came to be regarded as belonging to the Ontaric, to which place it had been assigned by Vanuxem. Among the reasons advanced for regarding the Oneida as Ontaric was the presence of Fucoids, either identical or closely allied with A r t h r o p h y c u s   a l l e g h a n i e n s i s , a fossil very common in the upper portion of the Medina sandstone.[1]

On the other hand, the stratigraphic position of the Oneida given by Vanuxem as above the Medina has, in the past, not been retained. In nearly all publications from Vanuxem's report to the present time, the Oneida when considered as a distinct formation has a position below the Medina. In this connection it is interesting to note that in a letter to one of the editors of the *American Journal of Science* [Ser. 2. 1864. 38:121], Col. E. Jewett, " states that he has found A r t h r o p h y c u s   h a r - l a n i , a characteristic Medina fossil, in the Oneida conglomerate, near Utica, Oneida co., N. Y., and also as he observes, for stratigraphical reasons, that the Oneida conglomerate is in fact only a northern portion of the Medina sandstone. The occurrence of this or a related fucoid is stated by Dana in his *Manual of Geology* [1863, p. 230], a specimen having been obtained from the rock near Utica by the author more than 30 years since, which was in all probability of the same species, although, as

[1]Dana, J. D. Manual of Geology. 1863. p. 231.

the specimen was afterward lost, the fact is given in the Manual with a query as to the species."

It is a noteworthy fact that in reviewing the works which have been published relating to the Oneida conglomerate and specially those which consider the Oneida as below the Medina, one can scarcely find anywhere a reference which attempts to show or even infer that Vanuxem's conclusion was not a correct one. It is also not an easy task to show specifically how the Oneida came finally to be regarded by geologists as lying below the Medina.

It should be mentioned, however, that the Shawangunk grit was regarded by all the early geologists as the stratigraphic equivalent of the Oneida conglomerate—a correlation which no longer holds good, the two terms being used as synonyms. Since we have red shales lying above the Shawangunk conglomerate, the same condition may have been assumed for central New York and thus the order of the beds determined.

Again the overlapping of the upper part of the members of the Ontaric system in central New York was formerly regarded as a thinned portion of the whole formation and not of the upper part alone as is now known to be the case.

The critical section for the stratigraphic position of the Oneida conglomerate is along the Oswego river. At the mouth of the river and along the shore of Lake Ontario we find the typical gray Oswego sandstone. Above the city and along the river banks, one can see that above the Oswego sandstone we have the red sandstones and shales of the Medina. These rocks show at intervals, and are specially well shown 12 miles farther south at the city of Fulton, at which place we have the falls of the Oswego about 10 feet in hight. The fall is due to the resistant character of the rocks and an examination shows that the rock is a quite coarse conglomerate, in which the fossil Arthrophycus alleghaniensis is found in great abundance and in a fine state of preservation. The rock above the fall can not be observed but enough is known to show that the conglomerate is not far below the Clinton formation.

In New York, the fossil Arthrophycus alleghaniensis Harlan is found in the Oneida conglomerate near Utica, at its type section in Oneida county, at the falls of the Oswego, and in the upper Medina west to the Niagara river. It is also found in Canada. Throughout this section this fossil is practically limited to the upper portion of the Medina and is thus important as an horizon marker. The presence of this

fossil and the stratigraphic relations of the Oneida conglomerate as shown in the Mohawk valley can leave no doubt of the upper Medina age of the Oneida conglomerate.

The presence of the fossil A r t h r o p h y c u s a l l e g h a n - i e n s i s   Harlan in Pennsylvania, Maryland and Virginia is of special interest.   Vanuxem[1] in referring to Pennsylvania says:

There this fossil appears in the same position, and in sand-stone of like diversity of character as to color, etc., as in New York generally.   It is abundant on the Juniata, and on the west branch of the Susquehanna.   I found this remarkable fossil in Virginia, about 15 years ago, near the top of the Flat-top moun-tain, a little to the west of the Salt valley above Abingdon.   It was in white sandstone, which caps that mountain, and which rests upon a red sandstone reposing upon a gray or olive cal-careous sandstone containing numerous testaceous fossils, refer-able rather to those of the sandstone shale of Pulaski [=Lorraine], than to any other part of the New York system.

The later work by Stevenson[2] also shows that this fossil is found in the upper Medina of Pennsylvania.

In Maryland[3] the lower portion of the Medina is known as the Juniata formation and the upper portion as the Tuscarora forma-tion.   No fossils are mentioned as coming from the former and Arthrophycus is the only one mentioned as occurring in the latter.

The Tuscarora is regarded as, " perhaps nearly identical with the White Medina of the Pennsylvania and New York surveys."

In Wills Creek gorge in Maryland, Professor Schuchert[4] has constructed the following descending section for the Medina.

1   Tuscarora.   Snow-white to light gray quartzite, in places a fine conglomerate; A r t h r o p h y c u s h a r l a n i the only fossil—287 feet.
2   Juniata.   Interbedded dull red sandstones and shales.   In Wills Creek gorge 530 feet can be seen, but the total thick-ness, on the basis of that in Bedford county, Pennsylvania, is probably not less than 730 feet.
3   " Hudson River shales."

From the above it will be seen that the fossil A r t h r o p h y - c u s   a l l e g h a n i e n s i s Harlan. wherever known, is most characteristic of the upper Medina and appears to be practically confined to this horizon and that from both stratigraphic and paleontologic reasons, the Oneida conglomerate is to be con-sidered as a part of the upper Medina.

[1]Geol. N. Y. 3d Dist. 1842. p. 71.
[2]2d Geol. Sur. Pa. Rep't of Progress. T2. 1882. p. 91.
[3]Md. Geol. Sur. Allegany Co. 1900. p. 86.
[4]U. S. Nat. Mus. Proc. 1903. 26: 424

In another work, the writer[1] has described the Medina of New York under two divisions, namely the lower and the upper, which may be regarded as corresponding to the Juniata and Tuscarora of Pennsylvania and Maryland. The passage from the lower to the upper is marked by a change in character of sedimentation and in the color of the rock. At the Niagara river, the lower red shales are followed by about 25 feet of gray quartzose sandstone. This bed of sandstone corresponds approximately to the base of the Oneida or upper Medina from Oneida county eastward, both occurring at a little more than 100 feet below the base of the Clinton. This gray sandstone marks the introduction of marine life into the Medina. At Niagara the gray quartzose sandstone is followed by a series of thin shales and sandstones and is terminated above by the " gray band " which is the upper limit of the Medina.

It was pointed out in a previous paper[2] that the Shawangunk conglomerate of eastern New York, probably represented an age later than the Oneida, with which it had been generally correlated. Though at that time the Oneida conglomerate was regarded as of the same age as the Oswego sandstone, the present study shows still more clearly that the Shawangunk conglomerate should not be regarded as basal Medina, but as Salina.[3]

In a recent publication,[4] Dr. A. W. Grabau has regarded the Oneida as a basal conglomerate, which, in age, ranges from the lower (=Oswego sandstone) Medina to the upper Medina. In this connection it should be noted that at the type locality for the Oneida, which is near Verona in Oneida county, the conglomerate is just below the Clinton and that this relation to the Clinton holds for 40 miles eastward to beyond Vanhornsville in Herkimer county, where is shown the last known exposure of the Oneida to the east, and thus this formation throughout this extent must be of upper Medina age.

This fact, together with the Oswego river section, tends to show that the Oneida wherever known holds a position which is never far below the base of the Clinton. Hall[5] records the finding of a conglomerate or pudding stone at the top of the Medina at Wolcott in Wayne county. A similar reference is also made to this locality in one of Hall's district reports.[6] As the top of

[1]N. Y. State Mus. Bul. in press.
[2]N. Y. State Pal. An. Rep't. 1903. p. 346.
[3]The reasons for considering the Shawangunk conglomerate as of the age assigned above, are stated in a paper on "The Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region" in this bulletin.
[4]N. Y. State Mus. Bul. 92. 1906 p. 123.
[5]Geol. N. Y 4th Dist. 1843. p. 42.
[6]An. Rep't 4th Dist. 1838. p. 325.

the Medina is but a few feet above the lake at Wolcott, this locality probably represents the most westward extension of what may be regarded as the Oneida conglomerate.

Champlainic and the Ontaric or Upper Siluric contact

In all the recent publications on geology, the Oneida conglomerate when considered apart from the Medina is made the base of the Ontaric division. The Oswego sandstone which has been considered the westward extension of the Oneida has also been generally regarded as belonging to the Ontaric. From the considerations which have been stated, it follows that if we regard the Oneida as the base of the Ontaric, the lower red Medina and the Oswego sandstone must be considered as belonging to the Champlainic, or else the base of the Ontaric must be placed lower than the Oneida conglomerate.

It is not the purpose of the writer to here state just where the line between the Champlainic and Ontaric divisions should be drawn, but rather to state some of the factors which must be considered in the final solution of the problem.

In comparing the results of the early geologists, it should be remembered that Hall and Emmons included the Oneida conglomerate as the highest member of the Champlainic system and the Medina sandstone as the base of the Ontaric. Vanuxem on the other hand regarded the Oneida as above the Medina and made the gray Oswego sandstone, which is below the red Medina, the base of the Ontaric.

The later works of Hall show that he finally included the Oneida as the base of the Ontaric, but always held that the Oneida was below the Medina.

From Oneida county eastward, the Oneida conglomerate rests on the Champlainic strata and represents the base of the Ontaric as at present defined, only in the sense that it is the lowest Ontaric formation present. In a like manner the higher Ontaric formations rest on the Champlainic strata, the farther east we go, and at Becraft mountain, the Manlius, the highest member of the Ontaric, rests on unconformable Champlainic strata.

The passage of the Lorraine into the Oswego sandstone can be observed in Oswego county and has been described by Vanuxem.[1] It is then evident that we have no unconformity between the Lorraine and the members of the Medina formation in Oswego county.

Of the condition in Pennsylvania, Stevenson[2] states, "the

[1]Geol. N. Y. 3d Dist. 1843. p. 67.
[2]Geol. of Bedford and Fulton Counties. 1882. p. 92.

passage from the Lower Medina to Hudson is imperceptible, and the red or brownish red shales yield A m b o n y c h i a r a d i a t a and R h y n c h o n e l l a c a p a x ."

Stevenson regarded the Oneida as below the Medina, but mentions the fact that the Oneida at this locality is absent and that the conditions as above stated prevail.

In Ohio and Indiana, the Richmond beds follow the Lorraine. The Richmond beds are fossiliferous and their fauna contains a number of Trenton forms. If we regard the Oswego sandstone as following directly the Lorraine in New York State, then the Richmond must, in part at least, be the time equivalent of the Oswego sandstone.[1]

At present the Oswego sandstone is regarded as Ontaric and the Richmond beds as Champlainic.

It is generally held that the Champlainic period was brought to a close by the Taconic revolution. In eastern New York the entire portion became land, but deposition continued in the vicinity of Oswego county, since the Oswego sandstone follows the Lorraine without break.

If we consider the Champlainic as being brought to a close with the beginning of the Taconic revolution, then the Oswego sandstone could be made, as it is at present, the base of the Ontaric.[2] The Oswego sandstone is practically without fossils, so from a basis of paleontology alone it can not be correlated with the Richmond beds. It seems, however, that the Oswego sandstone represents a near shore condition which was unfavorable for the existence of life but farther west the Richmond fauna flourished under more suitable conditions. The very marked paleontologic break at the close of the Lorraine is another factor in favor of making the Ontaric begin at the base of the Oswego sandstone.

The absence of a Richmond fauna from this section of New York is then to be accounted for by the changes in conditions of sedimentation rather than by an hiatus at the close of Lorraine time. There is a possibility that a fauna closely allied to that of the Richmond may yet be found in New York, in which case it would have an important bearing on the subject. The presence of such a fauna, however, is considered not very probable.

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[1] *See* Pal. Minn. 1897. v. 3, pt. 2, p. ciii.

Note.— Grabau states, "If no unconformity exists between the Upper Richmond and the Mayville beds and if the latter are of the age of the Clinton of New York, the lower Medina shales of the Niagara region resting upon the Lorraine, must be of Richmond age." N. Y. State Mus. Bul. 92. 1906. p. 124.

[2] The value of subsidences and emergences as a basis for stratigraphic classification is stated by Ulrich and Schuchert in the annual report of the New York State Paleontologist for 1901, p. 659.

UPPER SILURIC AND LOWER DEVONIC FORMATIONS OF THE SKUNNEMUNK MOUNTAIN REGION

BY

C. A. HARTNAGEL

Introduction

The Upper Siluric and Lower Devonic formations of the Skunnemunk mountain region, in the vicinity of Cornwall,[1] Orange co., N. Y., are the extreme northeastern portion of a great outlier of rocks which extends from near Cornwall station southwestward into New Jersey for a total distance of about 50 miles.

The general structure of the rocks of this area is that of a great syncline which is, however, much modified by secondary folds and by faulting. The trend of this syncline is parallel to, and 23 miles southeast from, the main area of the formations of similar ages, which outcrop approximately along a line extending from Rondout, N. Y., southwesterly through Port Jervis and continuing into New Jersey.

Near the northern extension of Skunnemunk mountain, the Moodna river flows in a direction a little north of east. On reaching the end of the mountain, the river abruptly turns and flows southeasterly, in what is apparently a fault valley and across the strike of the Upper Siluric and Devonic formations. The river then again turns and flows towards the northeast and finally empties into the Hudson river at Cornwall-on-the-Hudson.

Within the V-shaped area made by the somewhat unusual course of the Moodna river, there is a comparatively small syncline, and it mainly is to this section that this paper will be restricted.

Previous work on this area. The rocks of this section have been differentiated since the early days of the New York State Geological Survey. Forming as they do an outlying area, they have naturally offered to the geologist an opportunity for careful comparative stratigraphic and paleontologic work. Horton was the first to give an account of this district [An. Rep't.

[1]Idlewild is the name of the postoffice at Cornwall station on the Newburgh branch of the Erie Railroad. This station is but a few hundred yards from the cut on the Ontario and Western Railroad. The nearest station of the latter road is at Orr's Mills less than ¾ mile away.

1st Dist. 1839. p. 151]. Later his views are quoted and discussed by Mather.[1] Prof. W. B. Dwight[2] has studied the region, specially the locality of the Townsend iron mine, to which reference will be made later. N. H. Darton,[3,4] in two papers, has given in detail some of the features of this area, and specially a good account of the New Scotland (=Delthyris shaly) fauna. Dr H. Ries[5] and E. C. Eckel,[6] have also briefly discussed the region. Recently Kümmel and Weller[7] have published a section of the formations exposed in the cut near Cornwall station.

The work to which this paper relates was taken up, partly with a view to the determination of interesting, though unexplained, conditions of overlap or faulting which had been noted by previous writers, and partly for the study of some of the Upper Siluric strata of whose age here as in other sections of the State there has been ground for some uncertainty. In carrying on this work the writer has had the advantage of suggestions and advice from Dr A. W. Grabau of Columbia University. To Dr C. P. Berkey, also of Columbia, are due thanks for assistance in the determination of field measurements and structural features.

Structure of the syncline. In the cut of the Ontario and Western Railroad, the syncline can be best observed. Here the distance between the top of the Shawangunk conglomerate as developed in the two limbs of the syncline is less than 500 yards. In the east cut the dip does not vary more than 2° from the vertical and the strike is n. 9° e., while in the west cut the dip is 75° s. e. and the strike is n. 40° e. The strike of the rocks as thus measured in this cut indicates a rapidly spreading syncline. In following along the strike of the outcrops, for ¾ mile, it is found that the limbs of the syncline are ⅔ mile apart and that, with the exception of some local changes where faulting has occurred and to which reference will be made later, the dip of the rocks has varied little from that observed in the railroad cut. From the nature of the fold, the rocks as shown in the cut can extend but a short distance to the northeast. The topographic relations indicate that they soon fail and the underlying rock is the " Hudson River " shale.

To the southwest, after about a mile, the formations of the syncline as exposed in the cut disappear in the low swampy ground. At about the point where the lower formations fail,

[1]Geol. N. Y. 1st Dist.   1843.   p. 351, 362, 490.
[2]Vassar Brothers Inst.   Trans.   1883–84.   2:74.
[3]Am. Jour. Sci.   1886.   31:209–16
[4]Geol. Soc. Am. Bul.   1894.   5:379–80.
[5]N. Y. State Geol.   15th An. Rep't.   1898.   p. 426–28.
[6]N. Y. State Geol.   An. Rep't.   1900.   p. 1147–49.
[7]N. J. State Geol.   An Rep't, 1901.   1902.   p. 17.

Plate 1

Vertical strata, east limb of syncline, in cut of Ontario & Western railroad, Cornwall station, N. Y.   Rondout water-
lime at left, Cobleskill and Decker Ferry formations at the right

midway between the outer faces of the syncline, the Oriskany and Cornwall (=Monroe) formations rise as a high elevation known as Pea hill.   This hill extends about a mile to the south where, at its base, the Moodna river flows and which, as already indicated, cuts off this area from Skunnemunk mountain.

At first sight it would appear that this trough is a pitching syncline, and its present condition produced as a result of greater erosion of the northeast end which here would bring the two limbs close together.   This, however, can be regarded as only one of the factors which indicate a spreading fold.   The nearly vertical strata in the railroad cut are conditions which could not have been brought about by any method of erosion alone, but it must be concluded that the narrowness of the fold at one end is indicative of an originally spreading fold and, therefore, that its present appearance is not due simply to erosion.

As the axis of this fold passes considerably to the east of the axis of Skunnemunk mountain, it is regarded rather as a local development and not an extension to the northeast of the main syncline which forms Skunnemunk mountain.

Geological formations.   The rocks involved in this area from the top downward are as follows:

Cornwall (=Monroe shales of Hamilton age)	
Oriskany sandstone	
Port Ewen (?) limestone	
Becraft (?) limestone	Devonic
New Scotland limestone	
Coeymans limestone	
Manlius limestone	
Rondout waterlime	
Cobleskill and Decker Ferry limestones	Upper Siluric
Binnewater quartzite } =Longwood shales	(Ontaric)
High Falls shale } of Darton	
Shawangunk conglomerate	

"Hudson River" shales..........Lower Siluric (Champlainic)

Cornwall shale.   For reasons stated below, this term is used in place of the name Monroe shales which was introduced by Darton[1] to designate the shales carrying a sparse Hamilton fauna, which are well developed in the towns of Monroe and Cornwall in Orange county.   In view of the fact that the name " Monroe beds " had been used by Dr A. C. Lane to include all the rocks between the Niagara and Dundee limestones of Michigan, and also since there was some doubt as to the validity of the Michigan name, Professor Prosser submitted the matter to

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[1]Geol. Soc. Am. Bul. 1894. 5:374.

the Committee on Geologic Names of the United States Geological Survey, which sent the following reply[1]:

The Committee on Geologic Names on May 12th took action on the validity of the term Monroe in several publications of 1891, 1892 (1893), and 1895, as the name of a group of rocks distinguished in southern Michigan, as against the standing of the name published in 1894 for a shale formation in southeastern New York.

The committee recommended that the Monroe group of southern Michigan should retain the name, and this action has been approved for official publications of the geological survey.

The conclusion was reached on the ground that priority and prescription, or established usage, are combined in the Michigan application of the term in such a way as to make its continued use more desirable than that of Monroe shale in New York; but the case was not considered one in which priority was so definitely obvious as to justify the conclusion on the ground of the publication of 1891-92 (1893) only, since in that publication the definition was inadequate.

The Cornwall[2] shales are well shown at Pea hill where they have a thickness of at least 200 feet. They here appear as two steep ridges, which seem to conform to the synclinal structure of this area and form the highest points on the map east of the Moodna river. These shales are dark gray in color and in places a pronounced slaty cleavage is shown. The number of fossil species found in them is small, but the number of individuals of the same species is quite large. The best localities for collecting are in the old vineyard and the woods on the south side of the east cliff, and on the steep western face of the west cliff. The fossils found are usually distorted and not well preserved. Darton[3] mentions a locality on the south side of Pea hill where is an inconspicuous outcrop of fine grained red and gray sandstone in which the following genera were observed:

1 Chonetes   5 Spirifer
2 Meristella   6 Tentaculites
3 Orthis   7 Theca
4 Rhynchonella

Oriskany formation. So far as is known the Oriskany lies directly below the Cornwall shales in Pea hill. The contact between these formations at this place has not been observed, so it is at present impossible to tell the exact nature of the rock which directly overlies the Oriskany. In New Jersey, Kümmel

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[1]Geol. Sur. Ohio. 1905. Ser. 4. Bul. 7, p. 26.
[2]The expression Cornwall limestones has been used by Eckel to designate the limestones of this area which in age range from the Decker Ferry to the New Scotland. He says, "the term 'Cornwall limestones' is not here proposed as a formation name, but is used merely as a convenient designation for the series till further field work shall have decided the extent to which subdivision can be carried." N. Y. State Geol. An. Rep't. 1900. p. 1148.
[3]N. Y. State Geol. 15th An. Rep't. 1895. p. 417.

UNIVERSITY OF THE STATE OF NEW YORK
EDUCATION DEPARTMENT.

JOHN M CLARKE
STATE PALEONTOLOGIST

BULLETIN 107

STRATIGRAPHIC MAP
OF THE
REGION ABOUT CORNWALL STATION
ORANGE COUNTY

Geology by C. A. Hartnagel

0   ¼   ½ mile

LOWER S

Hudson River
shales

340
360
380
400
420
440
460
480

LEGEND

DEVONIC

Cornwall shale

Oriskany quartzite

New Scotland beds

Coeymans limestone

UPPER SILURIC

Manlius limestone

Rondout waterlime

Cobleskill and Deckerferry limestones

Longwood shale

Shawangunk conglomerate

LOWER SILURIC

Hudson River shales
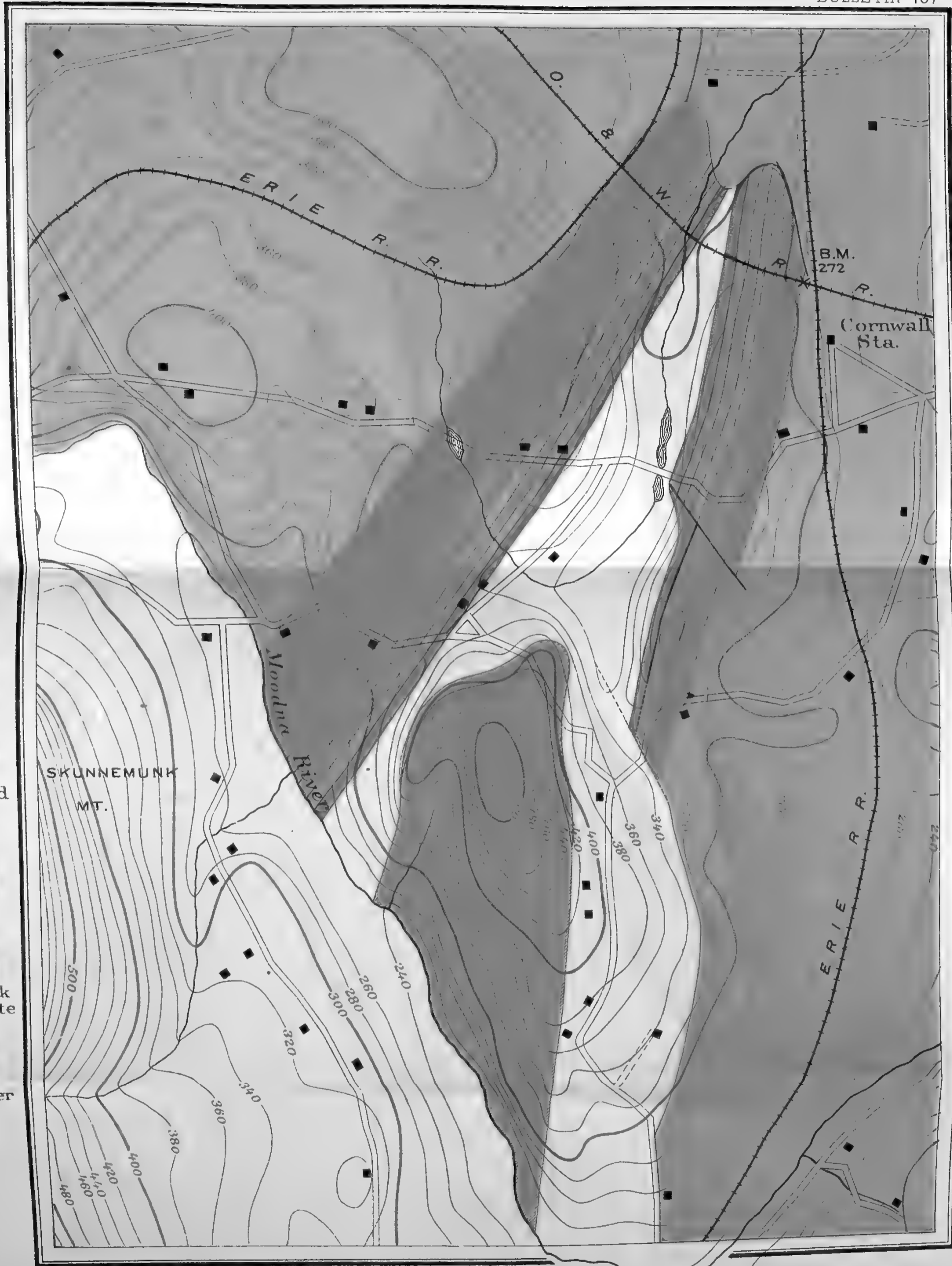
Geology by C. A. Hartnagel

STRATIGRAPHIC MAP
OF THE
REGION ABOUT CORNWALL STATION
ORANGE COUNTY

0   ¼   ½ mile
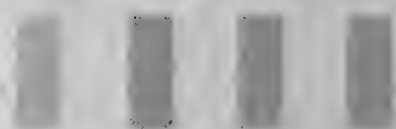
and Weller[1] have designated as the Newfoundland grit, a formation which is transitional into the Cornwall shale and which has an estimated thickness of about 215 feet. The fauna[2] of this grit is essentially that of the Onondaga limestone of New York. The Newfoundland grit[3] as defined by · Kümmel and Weller is as yet known only in the Green Pond mountain region.

The relations between the Newfoundland grit as defined by Kümmel and Weller and the Oriskany quartzite of the Skunnemunk mountain region is not entirely clear. In the New Jersey section under consideration, none of the Helderbergian rocks are shown, the highest known formation below the Newfoundland grit being the Decker Ferry beds, the upper part of which corresponds to the Cobleskill limestone. For the New York area I have retained the name Oriskany quartzite, which term has been used by Darton and by Ries for this quartzite in this region. For the present at least the retention of this term seems the most desirable, for the Helderbergian rocks, if not in actual contact with the Oriskany, are but a short distance below it. Moreover the quartzite at Pea hill is characterized by such Oriskany species as A n o p l i a   n u c l e a t a Hall, and L e p t o c o e l i a f l a b e l l i t e s Conrad. According to Kümmel and Weller the Newfoundland grit grades upward into the Monroe shales, without any line of demarkation. Two species from the Newfoundland beds, P t e r i n e a   f l a b e l l u m Conrad and A c t i n o p t e r i a   d e c u s s a t a Hall, as identified by Kümmel and Weller are Hamilton forms and they tend to show a close relation of these beds to the Hamilton formation. It is possible that future studies will indicate that the formation which I have here designated the Oriskany may represent a later return of Oriskany conditions and its fauna.

In this connection it should be noted that the Esopus, Schoharie and Marcellus formations which in the typical New York sections lie between the Oriskany and Hamilton formations, have as yet not been observed in the Skunnemunk mountain region.[4] The section that approaches most closely to the conditions of the Oriskany as found in the Skunnemunk region, both as regards nature of sediments and relation of the overlying rock, is that of central and western New York, which also includes the type section for the Oriskany sandstone. There the Oriskany, wher-

[1]Geol. N. J. An. Rep't. 1901. p. 18.
[2]N. J. Geol. Sur. Rep't on Paleontology. 1902 (1903). 3:105.
[3]The term Newfoundland quartzite was first proposed by Eckel for the quartzite typically exposed at Newfoundland, N. J. Eckel considered the rock to be paleontologically equivalent to the Oriskany quartzite. See N. Y. State Geol. An. Rep't. 1900. p. 1148.
[4]See Ulrich & Schuchert, N. Y. State Pal. An.Rep't. 1901. p. 654.

ever found, is always followed by the Onondaga limestone and
west of Syracuse rests upon the Upper Siluric strata. The varia-
tions of the silicious and calcareous sediments and of the varying
thicknesses along different meridional sections, as also the con-
ditions of sedimentation and distribution of the fauna of the
Oriskany of New York, have been stated in detail by Clarke.[1]

The Oriskany formation in the area studied outcrops at the
highway which crosses the north end of Pea hill and extends
into the fields below. It has a thickness of at least 50 feet and
it may be much thicker. The beds are light gray in color and
very massive and in some of the layers pebbles are abundant.
The rock is very hard and fossils are few and not readily obtained.
The following have been recorded by Darton from this locality:

Anoplia nucleata *Hall*	Leptaena rhomboidalis *Wilckens*
Leptocoelia flabellites *Conrad*	Stropheodonta, *sp ?*

Port Ewen and Becraft limestones. These formations, which
normally come in between the Oriskany and the New Scotland
beds, are not definitely known in this section. There is a covered
space between the New Scotland and the Oriskany, but the
ground is mostly low and swampy and not favorable for deter-
mining the nature of the intervening formations. There are,
however, a few outcrops which doubtfully may be referred to
the Becraft. The structural relations in this area, between the
Oriskany and the New Scotland beds, suggest that faulting may
have taken place.

New Scotland limestone. This formation is exposed in both
limbs of the syncline. In the west one there are small expos-
ures in the woods south of the railroad cut. In the east limb it
is exposed at several places and specially where pits have been
dug for limonite, to which reference will be made later. This
formation is the highest that can be observed for ¾ mile south
of the railroad, the interval between it, as exposed in the two
limbs of the syncline, being occupied by a swamp. The entire
thickness of the formation could not be measured, but its
exposed thickness is not less than 40 feet. These beds are very
fossiliferous and shaly, and from ½ cubic meter of shale Darton[2]
collected more than 40 species.

Coeymans limestone. This formation is but obscurely shown
in the west limb of the fold. There is a small exposure in a
depression just south of the railroad. Other unimportant expos-
ures are seen in the woods beyond. The formation is best shown

[1]N. Y. State Mus. Memoir 3. 1900. p. 65, 75, 78.
[2]Am. Jour. Sci. 1886. 31: 214.

in the east cut where its thickness is 40 feet. This probably represents the entire thickness, as the upper portion begins to show New Scotland characteristics. The upper part is a very coarse, porous, cherty limestone and contains abundant fossils. The lower part is not so cherty and has more of the aspect of the Manlius, though it also has many fossil remains. Near the base of the formation the rock contains fragments strikingly similar to the Manlius. This is of special interest as the base of the Coeymans marks the lower limit of the Devonic. Other outcrops of the Coeymans can be seen near the highway which crosses this formation farther south. It also shows in some excavations that have been made for limonite and in a small quarry south of the highway above mentioned. A little beyond this quarry the Coeymans and all the lower formations down to the Longwood shales are cut off by faulting.

Manlius limestone. This formation has a thickness of 7 feet. It here appears as a massive limestone, but otherwise has the features of the Manlius. The thinness of the formation in this section is unusual and from the fact that the base of the Coeymans contains fragments of what appear to be Manlius and also from the small thickness one is led to believe that the upper part of the Manlius has been eroded before the deposition of the Coeymans. The studies of Dr Grabau[1] at Becraft mountain indicate that the change from the Manlius to the Coeymans was a gradual one. Similar results have been reached by the study of the Manlius in New Jersey and central New York. Van Ingen and Clark[2] give evidence to show that the Manlius was slightly eroded before the deposition of the Coeymans. Fossils are rarely found in the Manlius as exposed in the cut. H o l o - p e a   a n t i q u a Vanuxem is the most characteristic, while L e p e r d i t i a   a l t a Conrad and T e n t a c u l i t e s   g y r a - c a n t h u s Eaton are occasionally seen. The Manlius extends south to the fault previously mentioned. The contact with the Coeymans may favorably be seen in a small quarry south of the highway. The Manlius has not been observed in the west limb of the syncline.

Rondout formation. This is rather a massively bedded limestone with some thin partings of shale. The formation is 13 feet thick and at about the middle there is a very sandy layer about 1 foot thick. This layer shows cross-bedding and although slight it is very distinct. The upper part of this formation shows the distinctive sun cracks of the Rondout as

[1]N. Y. State Pal. An. Rep't. 1902. p. 1052–54.
[2]N. Y. State Pal. An. Rep't. 1902. p. 1186.

exposed at many other places in the State. Some Favosites were found in the Rondout at the railroad cut. The lower part of the formation is transitional into the beds below and in one of the beds near the base of the Rondout there is an abundance of Cladopora rectilineata Simpson, a fossil very characteristic of the Cobleskill limestone of eastern New York and New Jersey.

Cobleskill and Decker Ferry limestones. The Cobleskill limestone was formerly correlated as Niagaran, but it is now known to be above the Salina. In this cut the Cobleskill and Decker Ferry formations will be described together since for lack of fossils it is not easy to state where the division between them should be drawn. The total thickness of these two formations is 35 feet. The upper 30 feet are characterized by the great abundance of the small coral Cladopora rectilineata Simpson which gives to the rock a mottled appearance. Fossils other than the corals were not found. This coral, it should be observed, is also very abundant in the Cobleskill and Decker Ferry at the Nearpass section in New Jersey. In color the rock is of various shades of brown. There are seams of shaly matter between some of the more massive beds. The upper 10 feet are finer grained and more subject to fracture and shattering. The lower 20 feet are more silicious and compact and in position correspond with the Rosendale cement bed as shown in Ulster county. The lower 4 feet are characterized by the absence of corals and by the presence of the following species:

Atrypa reticularis *Linne*
Camarotoechia litchfieldensis *Schuchert*
Chonetes jerseyensis *Weller*

Longwood shale (High Falls shale and Binnewater quartzite). This term was introduced by Darton[1] to designate the red shales and light colored quartzites which in the region under consideration and in that extending farther southwestward into New Jersey, occupy a position between the Helderberg (=Decker Ferry in part) limestones and the Shawangunk conglomerate (=Green Pond). Darton states [p. 382]: "There are similar shales having the same relations in Ulster county, N. Y., where they have been considered equivalent to the Clinton formation." In 1894 Darton[2] published a section in Ulster county where the red shales above the Shawangunk conglomerate were designated the Medina and the name Clinton was used for the quartzites above the red shales. As the names Medina and Clinton were

[1]Geol. Soc. Am. Bul. 1893. 5: 382.
[2]N. Y. State Mus. 47th An. Rep't. 1894. p. 530, fig. 8.

shown to be no longer applicable to the formations bearing these names in eastern New York, the writer has used the terms High Falls and Binnewater for Medina and Clinton respectively.[1]

The Binnewater quartzite has generally been considered as of Clinton age. This correlation was made partly on account of its similarity to some of the Clinton beds in central New York and also from the fact that both it and the green Brayman shales formerly supposed to be of Clinton age and which underlie the Cobleskill limestone at Schoharie, contain iron pyrites.[2] The reasons for regarding the Binnewater quartzites as of a later age than the Clinton have been stated in previous publications.[3,4]

The Binnewater quartzite is not well developed in the railroad cut at Cornwall. Under the description of the Longwood red shales Darton states[5]: "In this cut, which is their northernmost exposure, the upper members are light colored, thin bedded quartzites, which have a thickness of 12 feet, and closely resemble the quartzites similarly lying between the waterlime and red shales in the Rosendale cement region of Ulster county." It is evident, however, that of this thickness all but 1 foot belongs to the Decker Ferry formation. Above the red shales there is 1 foot of shaly brecciated limestone, which has the stratigraphic position of the Binnewater quartzite. Immediately above this brecciated layer, characteristic fossils of the Decker Ferry are found, showing that the Binnewater is here represented by a thickness of 1 foot. The brecciated character of this bed indicates a local stratigraphic break which is not so clearly observed in any of the other sections studied.

In Ulster county the change from the Binnewater quartzite to the Wilbur limestone (=Decker Ferry in part), or to the Rosendale cement where the Wilbur is absent, is an abrupt one. This change appears to be due to rapid subsidence which made the shore line at a greater distance and thus the finer calcareous deposits were laid down over the quartzites.[6] The studies made indicate that the Binnewater quartzite was followed closely by the deposition of the overlying limestones. In this connection it is well to note Darton's[7] statement that "The Helderberg (=Decker Ferry in part) limestone usually lies on and merges into the Longwood shales." Kümmel and Weller[8] state: "The

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[1]N. Y. State Pal. An. Rep't. 1903. p. 345, 346.
[2]Geol. N. Y. 1st Dist. 1843. p. 354.
[3]N. Y. State Pal. An. Rep't. 1902. p. 1175.
[4]N. Y. State Pal. An. Rep't. 1903. p. 345.
[5]Geol. Soc. Am. Bul. 1903. 5: 382.
[6]See Grabau, N. Y. State Mus. Bul. 92. 1906. p. 125.
[7]Geol. Soc. Am. Bul. 1893. 5: 391.
[8]Geol. N. J. An. Rep't. 1901. p. 41.

passage upward from the conglomerates into the quartzites, thence to the Longwood shales, and finally to the Decker Ferry limestones indicates a gradual but a steady advance of the ocean upon the land to the southeast."

In New Jersey at the Nearpass quarry section, which is just over the State line from Port Jervis in Orange county, N. Y., the Bossardville limestone is just below the Decker Ferry and below the former is the Poxino Island shale. As these two formations lying below the Decker Ferry are not found either in the Skunnemunk mountain region or the Rosendale region, they probably represent, in part at least, a deeper sea facies of the Binnewater quartzite.

In the railroad cut at Cornwall, the High Falls shales are 119 feet thick, and the transition to the Binnewater is well shown. The beds are coarser below and change gradually into the softer shales above. A few thin layers of lighter colored shale are found interbedded in the High Falls, but the shale is mostly a bright red. At the base some of the layers approach closely to a quartzite. Cleavage is often highly developed in the red shales, specially at the Townsend iron mine. The shale breaks into small angular fragments which are very abundantly shown along the southern end of the east limb of the syncline. The High Falls shale is almost nonfossiliferous. The only fossils found were some crinoids stems and several specimens of a small species of lamellibranch. The latter were from the red shale at the Townsend iron mine.

Shawangunk conglomerate. This conglomerate in the Green Pond mountain region of New Jersey has been called the Green Pond conglomerate. In the section studied the conglomerate is well exposed in both limbs of the syncline. The southern end of the west limb of the syncline is a high elevation made up almost exclusively of the conglomerate. The strata are nearly vertical and in places the surface is much worn and polished by glacial action. The measured thickness is 250 feet, which, however, does not represent the entire thickness as a portion of the conglomerate is concealed. The conglomerate is exposed at the railroad cut in both the east and west limbs of the syncline and in the east end of the cut the contact with the High Falls shale can be favorably seen. The conglomerate is characterized near the top by beds of pebbles alternating with beds of red quartzite without pebbles. The pebbles are mostly quartz and many have a diameter of 2 inches. The top of the conglomerate is marked by the last appearance of pebbles. The study of the High Falls

Plate 2

Glaciated hill of Shawangunk conglomerate with vertical strata.   West limb of syncline. Cornwall station, N. Y.

and the Shawangunk formations in this cut shows quite clearly that the High Falls shale follows the Shawangunk without break.

The passage from the Shawangunk (=Green Pond) conglomerate to the High Falls (=Longwood) shale is thus expressed by Darton[1]: "They [=High Falls] are also everywhere intimately associated with, and grade into the Green Pond conglomerate." Again [p. 384]: "The quartzites grade upward into the Longwood red shales, and the intergrading is exposed at a number of points along the west slope of Green Pond mountain and in New York. On the northwestern slope of Pine hill, beds of passage are finely exposed, and the red shale and red quartzite are interlaminated for a thickness of several feet." Also [p. 391]: "The Longwood shales are not known to overlap, for they merge into the upper part of the Green Pond rocks in all the exposure." Reference already has been made to the transition of the Shawangunk and the Longwood as stated by Kümmel and Weller.

The following is the section as shown in the east cut near Cornwall station:

		Feet
	DEVONIC	
1	Coeymans limestone...............................	40
	UPPER SILURIC	
2	Manlius limestone.................................	7
3	Rondout waterlime.................................	13
4	Cobleskill and Decker Ferry limestones...............	35
5	Longwood { Binnewater quartzite / High Falls shale }	120
6	Shawangunk conglomerate...........................	25
		___
	Thickness of the Upper Siluric rocks.............	200

In all the early work which relates to these formations and until very recently bed no. 4 of the above table, when recognized at all, has been regarded as Niagaran in age. It is thus easy to see that with this correlation of the Cobleskill the lower beds which are the Longwood and the Shawangunk would naturally be correlated with the Medina and Oneida respectively. In the same manner, assuming the Shawangunk to be equal to the Oneida, it would follow that the Cobleskill and Decker Ferry would be regarded as Niagaran. As we now know, however, that the Cobleskill is above the Salina and that all the lower formations follow without any break of importance as has been shown by the work of several writers, it follows that the Long-

[1]Geol. Soc. Am. Bul. 1893. 5:382

wood shales and the Shawangunk conglomerate must be regarded
as much later in age than formerly supposed and as has already
been suggested, the Shawangunk in this portion of the State
represents the invading basal member of the Salina.

Recent determinations have shown that the Oneida conglom-
erate is no longer to be considered as the basal member of the
Medina, but that it belongs to the upper part of the Medina
series. This determination in regard to the higher stratigraphic
position of the Oneida demonstrates to a certain extent that the
Shawangunk is not to be regarded as basal Upper Siluric.[1]
The higher stratigraphic position now assigned to the Oneida
makes the time interval between the Oneida and the Shawangunk
conglomerates less than formerly supposed when the Oneida was
considered as basal Medina. Some of the reasons for con-
sidering the Shawangunk as of Salina age have already been
given. Other reasons are as follows: The Shawangunk con-
glomerate rests on folded and eroded " Hudson River " strata.
That extensive folding and erosion had taken place previous to
the deposition of the Shawangunk is shown by the fact that in
some places these agents have brought to view exposures of
rock which from the faunal contents are regarded as the Nor-
manskill shale of middle Trenton age. The presence of Lor-
raine beds shows that deposition had continued until the close of
the Lorraine and therefore, to allow time for the folding and
erosion of the strata previous to the deposition of the Shawan-
gunk, we must regard this conglomerate as of later age than the
Oneida. The almost nonfossiliferous character of the strata
below the Decker Ferry beds indicates that they were formed
during Salina time rather than during the Niagaran period. The
period of the Shawangunk conglomerate was one of increasing
submergence[2] and on the east side of the Helderberg the suc-
ceeding formations progressively overlap the " Hudson River "
shales until finally at Becraft mountain the Manlius, the highest
member of the Upper Siluric rests unconformably upon the
" Hudson River " shales. From these conditions of overlap as
shown on both the east and west sides of the Helderberg the
evidence is in favor of regarding the Shawangunk as Salina, since
the latter on the western side of the Helderbergian barrier extends
much farther east than does the Niagaran and in the same way
the higher formations of the Upper Siluric are to be looked for
in the eastern section.

[1]See Grabau N. Y. State Mus. Bul. 92. p. 126.
[2]See Ulrich & Schuchert, N. Y. State Pal. An. Rep't. 1901. p. 647.

TABLE SHOWING RELATIONS OF THE UPPER SILURIC SECTIONS OF
EASTERN NEW YORK WITH THE WESTERN NEW YORK SECTION

Western New York	Port Jervis, Orange co.	Ulster co.	Cornwall, Orange co.	Previous correlation for Eastern New York and New Jersey
Cobleskill Salina series Bertie Camillus Syracuse Vernon	Cobleskill Salina series Decker Ferry Bossardville Poxino Island	Cobleskill Salina series Decker Ferry (Rosendale cement & Wilbur lime- stone)	Cobleskill Salina series Decker Ferry	} "Niagara"
Pittsford		Binnewater sandstone		
			Long-wood { Binnewater sandstone	Clinton
	High Falls shale(?)	High Falls shale	High Falls shale	Medina
	Shawangunk	Shawangunk	Shawangunk	Oneida
Guelph Lockport Rochester Clinton Medina including Oneida at top and Oswego sandstone at base	Unconformity	Unconformity	Unconformity	Unconformity
"Hudson River" beds	"Hudson River" beds	"Hudson River" beds	"Hudson River" beds	"Hudson River" beds

The subdivisions of the Salina series are not intended to show exact stratigraphic equivalents as read horizontally across the page, but rather the subdivisions recognized in the different sections.

In Rensselaer county there is a quite extensive plateau underlain by what is known as the Rensselaer grit. This formation has generally been regarded as basal Upper Siluric and correlated with the Oneida conglomerate or the Shawangunk conglomerate, the two latter being regarded as stratigraphically equivalent. If we regard the Rensselaer grit as basal Upper Siluric then this region must have been submerged shortly after the Taconic revolution. This, however, does not appear to be the case since the grit rests unconformably on strata which in age range from Lower Cambric to and including the " Hudson River " beds.[1]

The evidence furnished by the study of the Shawangunk grit and the Oneida conglomerate does not indicate that either of these formations extended as far as the region of the Rensselaer

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[1]Dale, T. N. U. S. Geol. Sur. Bul. 242. 1904. p. 51.

grit. There does not seem to be good evidence to show that
the sea covered this area after the Green Mountain uplift until
later Upper Siluric or Devonic time. This is made apparent
when we consider that the Rensselaer grit occupies an area that
was highly involved in the disturbances at the close of the Cham-
plainic period.

In tracing the Siluric formations north from Ulster county,
the Shawangunk conglomerate is the first to fail, and the suc-
ceeding formations fail by overlap in regular order until at
Becraft mountain in Columbia county the Manlius as already
pointed out rests unconformably upon the Champlainic strata.
This shows that as we approach the Rensselaer grit area, only
the highest members of the Upper Siluric are present, and the
conditions of overlap of these formations clearly indicate that
the Rensselaer grit is not of Shawangunk age.

In tracing the Upper Siluric formations eastward from central
New York, the Oneida is overlapped by the Clinton, and in
Albany county but 17 miles from the Rensselaer grit plateau, the
Manlius and a few feet of the Rondout are the only members of
the Upper Siluric present. From this it does not appear that the
Rensselaer grit can be correlated with the Oneida conglomerate.[1]
The submergences and emergences, which involve the conditions
of overlap following the Taconic revolution, have been stated in
detail by Ulrich and Schuchert.[2]

Structural relations of the Townsend iron mine. The Town-
send iron mine was first described by Horton[3] in 1839 as follows:
" Two and a half miles west of Canterbury, in Cornwall, is the
hematite or *limonite* mine of Mr. Thomas Townsend. For the
last two years this ore has been considerably used and although
a lean ore, it makes excellent iron. It is mostly in powder, or
very small fragments, mixed with balls and pieces of the hema-
tite, of a few pounds weight. It lies in a limestone rock, and
between the limestone and the grit rock. These rocks where
connected with the ore, are decomposed to great extent, and
mixed in a state of powder with the ore; hence the ore requires
washing."

This limestone was definitely correlated by Mather [4,5] with
what are now recognized as the New Scotland beds. He states,
" The S t r o p h o m e n a r u g o s a Dalman and S. r a d i a t a
Sowerby are very common fossils at the above locality, and the

[1]See Dale, U. S. Geol. Sur. Bul. 242. 1904. p. 53.
[2]N. Y. State Pal. An. Rep't, 1901, p. 647, 660.
[3]An. Rep't 1st Dist. 1838 (1839) p. 165.
[4]Geol. N. Y. 1st Dist. 1843. p. 351.
[5]See also plate 5, figure 14.

Plate 3

Townsend limonite mine near Cornwall station, N. Y.   Longwood red shale at the left, New Scotland beds at the right

rock is considered as belonging to the Catskill shaly limestone, which here has been upturned on its edges like the adjoining slate, grits and other rocks."

An examination of this mine was made by Prof. W. B. Dwight[1] who states, "that the limestones are of the lower Helderberg group, and that the adjoining red sandstone and conglomerate are not of the Triassic, like the New Jersey red sandstone, but are the Oneida conglomerate and the fine grained sandstone of the Medina epoch."

The geology in the vicinity of the Townsend iron mine has been studied in some detail by Darton.[2,3] His reports include the stratigraphic and paleontologic determinations and maps and sections of the region studied are given.

At the Townsend iron mine we find the strata nearly vertical and the New Scotland beds rest against the Longwood shales. This condition was noted by Darton, who states that it was due to faulting or thinning out of the formation below the New Scotland.

In the railroad cut the formations between the New Scotland and the Longwood shales are 95 feet thick. As the Townsend mine is but $\frac{1}{2}$ mile away from this cut and in the same limb of the syncline, it did not seem possible that the formation could thin out in such a short distance. On tracing the intervening formations south from the cut at a short distance south of the small quarry, just beyond the highway, the limestone formation below the New Scotland suddenly ceases and we come upon an area of red shale. The increased thickness of the Longwood shale at this point clearly indicated that they had been faulted. There is a small depression which marks the fault line passing at an angle and meeting another parallel to the strike of the rocks. It is evident that in faulting a wedge-shaped block was forced out carrying the limestone with it, the red shales thus coming into contact with the New Scotland. The steep ridge now left standing is composed of red shales, and it appears that only in very recent times has the limestone cap been removed and thus made possible this steep ridge of red shales. There are other indications of faulting in the vicinity of the mine. In some exposures the rocks are partly overturned and the red shales show induced cleavage. From the red shales at this mine a number of specimens of a lamellibranch were obtained. With

[1]Vassar Brothers Inst. Trans. 1883–84. p. 75.
[2]Am. Jour. Sci. 1886. 31: 209–10.
[3]Geol. Soc. Am Bul. 1893. 5: 379.

the exception of fragments of crinoids, these have been the only fossils recorded from the Longwood shales.

The iron taken from this mine is from the New Scotland beds and along the contact of the latter with the Longwood shale. The leached character of the red shales which are adjacent at once suggests the origin of the iron. A brief description of this mine together with the following analysis of the ore is given by Putnam.[1]

	Per cent
Metallic iron	28.57
Phosphorus	0.240
Manganese	Present
Phosphorus in 100 parts iron	0.840

A study of the geological relations at the mine shows that the presence of iron ore in the New Scotland beds is of local occurrence and is found only where the New Scotland beds are in contact with the Longwood shales. Several openings in the New Scotland beds north from the mine, have been made, but without finding any ore. An examination of these nonproductive openings shows that between them and the Longwood shale there are at least 80 feet of limestones, which indicates that this part of the syncline has not been affected by the faulting and that further exploitation for iron, of the New Scotland beds north from the productive mine will bring only negative results.

[1]Mining Industries of the U. S. 1886, p. 127.

MINERALS FROM LYON MOUNTAIN, CLINTON COUNTY

BY[1]

HERBERT P. WHITLOCK

Early in the spring of 1905 the attention of the writer was directed by Mr H. H. Hindshaw, geologist to the Delaware & Hudson Company, to some interesting occurrences of secondary minerals associated with the magnetite deposits of the Chateaugay mines at Lyon Mountain.

A visit to the mines made in the following summer resulted in the addition to the collection of the New York State Museum of about 150 specimens from this locality. This material augmented by a smaller collection made by Mr D. H. Newland, Assistant State Geologist, and a number of fine specimens presented to the museum as well as some loaned for study by Mr Hindshaw, forms the basis of the following paper. The writer wishes to express his thanks to the above gentlemen as well as to Thomas Cameron, at that time underground foreman, for many valuable suggestions as well as for aid in acquiring material.

GENERAL DESCRIPTION

The Chateaugay mines are situated at Lyon Mountain in Clinton county, about 23 miles west of Plattsburg and near the northern boundary of the area of Adirondack gneiss which forms the main outlying mass of the Adirondacks. The workings consist of a series of inclined shafts which in some instances extend to a vertical depth of 800 feet. It was for the most part in the deeper levels of the mine that the openings or "vugs" were encountered which furnished the greater mass of the material collected. One of the largest of these now accessible, situated at the 600-foot level, was some 15 feet in length by 3 feet wide and extended vertically to an unknown hight, the bottom being filled with blocks fallen from above. The walls of this cavity, where accessible, were thickly covered with hornblende, apatite, orthoclase and titanite in large and perfect crystals as well as many of the minerals later to be described, in matrix. Most of the calcite specimens of types III, IV and V were obtained from a still larger vug which formerly

extended across the ore body and was excavated previous to the writer's visit.   Most of the material collected from the dump heaps also showed evidence of the same vug formation.

Molybdenite

Molybdenite occurs closely associated with brown titanite in one of the smaller vugs opened on the 800-foot level close to no. 5 shaft.   The specimen obtained showed one bent and distorted crystal about 10 mm in diameter as well as several smaller ones, from which latter imperfect measurements were obtained which served to establish the presence of the pyramid ($20\overline{2}1$).   This pyramid, as shown by Moses,[1] is of comparatively frequent occurrence on measurable crystals of molybdenite, being found on the crystals from Frankford, Pa.; Aldfield, Quebec; Cape Breton, and Okanogan county, Washington.   The amphibole, titanite, phlogopite and quartz associated with the Lyon Mountain molybdenite showed marked evidence of partial resolution and were accompanied by secondary calcite, stilbite and pyrite.

Pyrite

Pyrite occurs abundantly in detached crystals of secondary origin associated with the orthoclase, hornblende, quartz and magnetite of the wall rock in the contact zone with the ore body. They consist of small but brilliant individuals averaging about 2 mm in diameter, the principal faces of which yield excellent reflections.

The examination of a large number of these failed to reveal any new or unusual forms, the prevailing habit being that shown in figure 1 which is identical with that found on the pyrite from Kingsbridge.[2]   The occurring forms are a (110), o (111), e (210), s (321) and n (211), the two latter being present only as narrow faces.

Quartz

Quartz of both primary and secondary derivation occurs abundantly in the contact zone.   The primary quartz occurs in rounded masses of variable size deeply furrowed and completely covered

[1]Moses, A. J.   Crystallization of Molybdenite.   Am. Jour. Sci. 1904.   167: 359.
[2]Moses, A. J.   Pyrite crystals from Kingsbridge.   Am. Jour. Sci. Ser. 3.   1893.   45: 488.

with parallel systems of wavy lines due to partial resolution. Several of these etched nodules which were obtained in a calcite matrix represented originally detached crystals. These roughly presented the form of oblate spheroids and though extremely rough on the surface reflected back the light from minute smooth surfaces in a manner suggesting the appearance of a cleavage fragment. On orienting one of these nodules in the reflection goniometer, it was found that the reflections from these corrosion surfaces in the circle of the transverse axis gave the angles of the prismatic zone for quartz. Furthermore, on reorienting the nodule, reflections were obtained from corrosion faces corresponding to the rhombohedral planes r ($1c\bar{1}1$) and z ($01\bar{1}1$) the angles agreeing fairly well with theory, considering the character of the faces measured.

Secondary quartz occurs with hematite, calcite and byssolite, all of later generation and derived from the redeposition of dissolved primary minerals, in brilliant crystals, transparent and for the most part colorless, but occasionally showing slight smokiness as well as inclusions of scaly hematite and prochlorite. A number of crystals were measured, several of which showed the rhombohedron Γ ($40\bar{4}1$) and the trapezohedrons x ($51\bar{6}1$) and q' ($10.1.\bar{11}.1$) the two latter being observed on right-handed crystals. In one instance a right trapezohedron was noted in the zone [$01\bar{1}0.11\bar{2}1.-10\bar{1}1$] which gave an angle corresponding to ($12.11.\bar{23}.11$) but as the face was not repeated on the same or other crystals, its accidental presence was assumed to be due to vicinal development. Figures 2a–2b show this habit.

The observed forms with the measured and calculated angles are given below:

	Forms	Angle	Measured		Calculated	
m	$10\bar{1}0$					
r	$10\bar{1}1$					
z	$01\bar{1}1$		°	′	°	′
Γ	$40\bar{4}1$	$10\bar{1}0:40\bar{4}1$	11	11	11	8
S	$11\bar{2}1$	$10\bar{1}0:11\bar{2}1$	37	51	37	58
x	$51\bar{6}1$	$10\bar{1}0:51\bar{6}1$	11	58	12	1
q'	$10.1.\bar{11}.1$	$10\bar{1}0:10.1.\bar{11}.1$	6	33	6	$31\frac{1}{2}$

Hematite

Secondary hematite derived from the magnetite occurs associated
with other minerals of the second generation such as quartz, calcite
and albite.   It is found in close aggregates of brilliant metallic
plates of the type shown in figure 3 the observed forms being c
(0001), r (10$\bar{1}$1) and n (22$\bar{4}$3).   A phase of this habit found in
close association with the secondary amphibole (byssolite), is
characterized by minute circular disks about 1 mm in diameter
consisting of flat rosettes of thin plates.   These have a red metallic
luster resembling that of burnished copper and show bright cherry-
red by strong transmitted light.   A specimen of quartz with which
these latter were associated was quite thickly covered with small
hemispheres of botryoidal hematite.   It is quite evident from this
specimen [pl. 8] that these three phases of the deposition of
hematite belong to the same period of genesis and were deposited
toward the end of the formation of secondary quartz.

Calcite

The several phases which mark the deposition of secondary
calcite are characterized by calcite crystals of definite habit.   Of
these crystal types, the first two stand distinctly apart from a
genetic point of view, whereas the last three are more or less closely
related both from the standpoint of crystal genesis and habit.

Type I.   Crystals of this type are found directly associated with
the corroded quartz orthoclase and amphibole, in most instances
deposited as a crust upon a highly corroded surface.   They are
distinctly scalenohedral in habit, the steep scalenohedron μ (54$\bar{9}$1)
predominating, modified in termination by the rhombohedrons M
(40$\bar{4}$1) and E (0.13.$\bar{13}$.4).   Figures 4a-4b and 5a-5b show this
habit.   The rhombohedron M is present in a bright series of planes
which furnished excellent points of reference.   The rhombohedron
E, on the other hand, gave faint but distinct reflections from a
series of dull and somewhat rounded surfaces.   On several speci-
mens the rhombohedron r (10$\bar{1}$1) is prominent in crystals of this
habit.   Several times during the measurement of crystals of this
type, a narrow plane beveling the acute polar edges of μ (54$\bar{9}$1) was
observed.   A rhombohedron in this zone would have the indexes
(0.13.$\bar{13}$.2) a form which seems doubly probable in consideration

of the fact that the presence of $(0.13.\overline{13}.4)$ has already been noted with reference to this type. No satisfactory reading could, however, be obtained.

The crystals which measure from 3 mm to 25 mm in length are, in some instances, filled with microscopic inclusions of quartz, hematite and matted byssolite, the latter forming a central nucleus of irregular shape, while the hematite, which was connected with a later stage of the crystal growth, appears in the outer layers in dendritic bunches.

Regarding the generation of calcite of this type it must be unquestionably placed at the base of the calcite series as shown at Lyon Mountain. The marked absence of pyramidal forms in the crystal habit and the presence of two modifying rhombohedra entirely absent from the varied types found in the later calcite deposition, set it distinctly apart as marking a separate genetic phase. At the same time the close association with primary minerals which show evidences of corrosion, points to the origin of this type from a highly corrosive crystallizing solution, rich in carbonate of lime but still far from saturated with silica and iron.

Type II. Calcite crystallizing in the forms of type II occurs incrusting the surface of joints in the ore body, in a confused aggregate of translucent, milky white crystals which exhibit none of the tendency toward parallel grouping of separate individuals noticeable in other types from this locality. The manner of the crystal massing suggests rapid deposition from a solution whose condition of concentration had been influenced by sudden cooling, change of pressure or some allied cause. Such a change of condition of concentration seems highly probable in the case of an open joint filled or partly filled with the crystallizing solution which from the nature of the case would be far more sensitive to the influence of currents.

The crystals of this type [fig. 6a–6b] which average 7 mm in diameter, are rhombohedral in habit and composed of "built up" forms, the predominating negative rhombohedron being deeply grooved by incipient modifications parallel to (0001) and $(01\overline{1}2)$. The rhombohedron Y $(0.19.\overline{19}.13)$ is present as a series of moderately brilliant but somewhat rounded faces; the form was determined by averaging the readings taken on 20 of the best crystals available. The scalenohedron $\mathbf{q}$: $(24\overline{6}1)$ is present, beveling the

basal edges of the predominating rhombohedron. Indications
pointed to a second scalenohedron in this zone giving the
indexes $(10.16.\overline{26}.3)$ and beveling the basal edges of **q**: as thin
lines from which measurements were obtained with great difficulty.
The form must be regarded as doubtful.

Type III.   Calcite crystallizing in forms of this type differs from
those previously described both in mode of occurrence and habit.
They occur for the most part embedded in masses of byssolite and
are often free or so loosely attached that doubly terminated indi-
viduals are readily obtained.   They are of a later generation than
those of type I, being contemporary and closely associated with
secondary quartz, hematite and albite derived from the minerals
accompanying type I.   In habit they are essentially pyramidal,
the simpler development showing the predominance of two pyra-
mids in the same series, $(8.8.\overline{16}.3)$ and $(22\overline{4}3)$ figure 7a, 7b.   More
complex   variations   of   this   habit   [fig. 8a–8b]   are   found
associated with these secondary minerals and, indeed, the remain-
ing types to be discussed may be said to represent phases of the
same conditions of deposition, as they are, at the same time, modi-
fied expressions of the same crystal habit.   The combination
shown in figure 7a, 7b represents this habit in its simplest develop-
ment and is found in crystals varying from 2 to 5 mm in vertical
length.   The pyramid γ $(8.8.\overline{16}.3)$ occurs as a series of bright,
sharp faces.   The faces of the pyramid Γ $(22\overline{4}3)$ and of the rhom-
bohedron Υ $(0.19.\overline{19}.13)$ are of fair brilliancy but frequently
roughened by natural etchings.   The planes of v $(21\overline{3}1)$ are often
present on this combination but of relatively small development.
On two crystals a terminating scalenohedron in the zone $[0.19.\overline{19}.-$
$13.19.19.0.13]$ gave measurements roughly corresponding to $(7.2.\overline{9}.11)$
but on account of the imperfect nature of the reflections the form
must be regarded as doubtful.

The combination shown in figure 8a-8b represents a modification
of this habit in which the planes of the scalenohedron v $(21\overline{3}1)$
partly replace those of γ and a second negative rhombohedron
l $(0\overline{4}45)$ terminates the crystal partly replacing the planes of Γ.
The alternate polar edges of γ are beveled by the scalenohedron
$\mathfrak{U}$: $(14.12.\overline{26}.5)$ in the zone $[8.8.\overline{16}.3.\overline{16}.8.\overline{8}.3]$.   This combination
which seems to indicate a slower and more perfect stage of crystal-
lization occurs in larger crystals than that previously described
under this type, detached crystals measuring from 4 mm to 30 mm
in vertical length.

Type IV. Figures 9a–9b show a combination resulting from the development of the negative rhombohedron A ($04\bar43$) which here replaces the planes of the pyramids γ and Γ to the extent of giving to crystals of this phase a rhombohedral aspect. The pyramids γ (8.8.$\bar{16}$.3) and Γ ($22\bar43$) which connect this combination with type III are present as faces of great brilliancy, as are also the planes of v ($21\bar31$). The rhombohedron A ($04\bar43$) here replaces $\hat{\Upsilon}$ as a series of brilliant planes which yield excellent reflections. Genetically this type corresponds closely with type III, the crystals occurring with considerable secondary quartz embedded in chlorite also of the second generation. The crystals are clear and faintly yellow in color and measure from 6 to 10 mm on the vertical axis.

A curious variation of this type was noted on a large mass of hornblende which was thickly incrusted with albite crystals.[1] These calcite crystals were symmetrically disposed in parallel position on the six basal angles of a positive rhombohedron r ($10\bar11$) the latter evidently of a previous growth and considerably etched and roughened on the surface. One of these composite crystals is shown in figures 10b–10c and an enlargement of one of the superposed secondary crystals in figure 10a. The secondary crystals of this phase bear a general resemblance to the modified combination of type III [figures 8a-8b] in that they show the scalenohedron $\mathfrak{U}$: ($14.12.\bar{26}.5$) beveling the alternate polar edges of the prevailing pyramid γ (8.8.$\bar{16}$.3). The pyramid π ($11\bar23$) in the same series with those previously noted appears as a terminal modification consisting of deeply striated faces. The scalenohedron μ ($54\bar91$) of type I here reappears for the first time as a series of small but brilliant faces. The negative scalenohedron $\mathfrak{q}$: ($24\bar61$) characteristic of type II is here represented by small brilliant faces; from both of these latter forms, excellent reflections were obtained. These two pyramids Γ ($22\bar43$) and γ (8.8.$\bar{16}$.3) are developed as large faces, the former giving fair reflections from somewhat dull surfaces, and the latter bright and sharp reflections. The three pyramids lie well in zone and agree closely as to measured and calculated angles. The composite crystals as shown in figures 10b–10c vary in size from 4 mm to 30 mm in diameter measured on a basal axis. The superposed crystals frequently unite to form a band encircling the primitive rhombohedron which latter in many instances shows incipient forms of this habit irregularly disposed

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[1]The writer is indebted to Mr H. H. Hindshaw for the loan of this handsome specimen as well as for material taken from it for study.

on the rhombohedral planes in parallel position; these latter, how-
ever, are microscopic and only serve to accentuate the character-
istic grouping habit.

Type V.   Crystals of this type were noted on a single specimen,
which differed little, with respect to the association and general
deposition of the secondary minerals, from the specimens producing
types III and IV, but which showed a much lower percentage of
secondary quartz crystals than these latter.   Several small crystals
of transparent apatite were noted on this specimen.   In habit these
crystals are far more complex than any hitherto described from
this locality, the combination shown in figures 11a–11b consisting
of no less than 11 forms.   In size and brilliancy they also exceed
the previously described types averaging 12 mm in vertical length
and beautifully developed in clear and sharp faces, all of which,
with the exception of l ($04\bar{4}5$) gave fine reflections of the goni-
ometer signal.   In general, indications seem to connect this type
with a slower action of the crystallizing solution producing more
perfect and highly modified individuals.

A clearly marked rhombohedral zone consisting of l ($04\bar{4}5$), A
($04\bar{4}3$), f ($02\bar{2}1$), Δ ($07\bar{7}2$) and Σ ($0.11.\overline{11}.1$) characterizes the
crystals of this type, the faces of which are small but clearly
defined. γ ($8.8.\overline{16}.3$) the predominating pyramid of types III and
IV is wholly lacking from this combination, its place being taken
by $\propto$ ($44\bar{8}3$) a form not hitherto noted from this locality but
which completes the series of pyramids by supplying a logical
link in the sequence between ($22\bar{4}3$) and ($8.8.\overline{16}.3$) the former of
which is present as a highly developed series of planes giving very
fair reflections.   Two negative scalenohedrons **p**: ($246\bar{1}$), which
was also noted in types II and IV, and C: ($347\bar{2}$) are present as
large and well developed forms.   The positive scalenohedrons v
($21\bar{3}1$) and R: ($8.4.\overline{12}.1$) are present as well developed forms.   A
regular and symmetrical roughening was noted on the obtuse polar
edges of v ($21\bar{3}1$) as shown in figure 11b which was probably due to
some twinning tendency,[1] although no twins were observed in con-
nection with this type.

The complex zonal relations between the various forms occurring
on the calcite from Lyon Mountain are shown in the stereographic
projection, figure 12 and are particularly well illustrated in the

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[1] In this connection it is interesting to note that the calculated values of ϕ for ($21\bar{3}1$) and ($426\bar{1}$)
differ by but 30″ and that consequently a penetration twin parallel to (0001) would bring the
superposed planes of these two forms in close orientation and might result in a vicinal roughen-
ing similar to that observed.

combinations of type V which includes 11 of the 19 forms observed for the locality. Assuming the principle announced by Cesaro[1] "that when a crystal of calcite is formed around a preexisting crystal, in general the edges of the first crystal tend to be replaced by faces which are parallel to them; i. e. a face of the new crystal is in zone with two faces of the original one." The superposed groups of type IV present a striking instance of harmony in zonal relations, and indeed the gradual increase in the numbers of forms from type I through types III, IV and V shows a close coincidence with Cesaro's principle.

GENETIC RELATIONS

In a former paper[2] the writer has referred to the pyramidal habit of the calcite crystals of Union Springs and has attempted to connect the pyramidal habit with a crystallizing solution heavily charged with dissolved silica. The conclusions drawn from the Union Springs occurrence, where a single pyramid γ $(8.8.\overline{16}.3)$ was used as a basis of comparison between the Union Springs calcite and that from Rhisnes and Andreasberg, gain added force in the case of Lyon Mountain, where a series of four pyramids occur in the various types, all four of which pyramids are found on the Rhisnes calcites and three of which also occur on the Andreasberg crystals. The dominant form of a combination illustrated by Luedecke[3] under type VIII from Jacobsglück vein, Andreasberg, μ $(54\overline{9}1)$, is identical with the dominant form of type I from Lyon Mountain. He notes this type as occurring sparingly with quartz which latter mineral has a "*hacked, corroded appearance.*" The mine waters from this immediate locality carry considerable gypsum, epsomite, limonite and hematite in solution and give evidence of having been strongly corrosive. These facts are in perfect accord with the conditions noted in connection with type I from Lyon Mountain [p. 59], and it seems highly probable that in the case of the Jacobsglück vein, Andreasberg and the Lyon Mountain localities, the first stage of calcite deposition took place from a highly corrosive solution which was taking up silica while depositing crystals of the steep scalenohedral habit of calcite. The absence of all secondary quartz in connection with this habit in both localities, points to the fact that the primary quartz in both cases was still

[1]G. Cesaro. Les formes crystalline de la Calcite de Rhisnes. Ann. de la Soc. Geol. de Belgique. 1889.   16:167.
[2]Whitlock, H. P. Calcite from Union Springs, Cayuga county. N. Y. State Mus. Bul. 98, p. 15–16.
[3]Luedecke, Otto. Die Minerale des Harzes, Berlin 1896, pl. XX, fig. 1.

being dissolved and its subsequent appearance with calcite crystals
of a later generation, which latter are characterized by an unusual
series of second order pyramids seems to connect, beyond question,
the pyramidal habit of calcite with a crystallizing solution satu-
rated or nearly saturated with silica.

SUMMARY OF DISTRIBUTION OF FORMS

Letter	Indexes	Type I	Type II	Type III	Type IV	Type V	
π	$11\bar{2}3$				+		
Γ	$22\bar{4}3$			+	+	+	
$\propto$	$44\bar{8}3$					+	
γ	$8.8.\overline{16}.3$			+	+		
M	$40\bar{4}1$	+					
r	$10\bar{1}1$	+					
l	$04\bar{4}5$			+		+	
A	$04\bar{4}3$				+	+	
Υ	$0.19.\overline{19}.13$	·	+	+			New
f	$02\bar{2}1$					+	
E	$0.13.\overline{13}.4$	+					New
$\varDelta$	$07\bar{7}2$					+	
Σ	$0.11.\overline{11}.1$					+	
v	$21\bar{3}1$			+	+	+	·
μ	$54\bar{9}1$	+			+		
$\mathfrak{U}$:	$14.12.\overline{26}.5$			+	+		New
$\mathbf{R}$:	$8.4.\overline{12}.1$					+	
$\mathbf{q}$:	$24\bar{6}1$		+		+	+	
c :	$34\bar{7}1$	•			+	+	

SUMMARY OF MEASURED AND CALCULATED ANGLES

Letter	Indexes	Type	Angle	Number of readings	Measured		Calculated	
					°	′	°	′
π	$11\bar{2}3$	IV	$11\bar{2}3:2\bar{1}\bar{1}3$	6	28	15	28	39
		IV	$11\bar{2}3:8.8.\overline{16}.3$	1	47	37	47	57
Γ	$22\bar{4}3$	III	$22\bar{4}3:4\bar{2}\bar{2}3$	2	44	2	44	8½
		IV	$22\bar{4}3:4\bar{2}\bar{2}3$	1	44	12	44	8½
		V	$22\bar{4}3:4\bar{2}\bar{2}3$	2	44	10½	44	8½
		III	$22\bar{4}3:8.8.\overline{16}.3$	6	28	48	28	54
		IV	$22\bar{4}3:8.8.\overline{16}.3$	3	28	52½	28	54
$\propto$	$44\bar{8}3$	V	$44\bar{8}3:8\bar{4}\bar{4}3$	1	54	23	54	30
		V	$44\bar{8}3:2\bar{1}\bar{3}1$	2	10	26	10	27

SUMMARY OF MEASURED AND CALCULATED ANGLES (*concluded*)

Letter	Indexes	Type	Angle	Number of readings	Measured		Calculated	
γ	8.8.$\overline{16}$.3	III	8.8.$\overline{16}$.3:16.$\overline{8}$.$\overline{8}$.3	3	58	28	58	28
		IV	8.8.$\overline{16}$.3:16.$\overline{8}$.$\overline{8}$.3	1	58	33	58	28
		III	8.8.$\overline{16}$.3:8.8.$\overline{16}$.$\overline{3}$	4	24	37	24	46
		IV	8.8.$\overline{16}$.3:8.8.$\overline{16}$.$\overline{3}$	2	24	40	24	46
M	40$\overline{4}$1	I	40$\overline{4}$1:01$\overline{1}$1	5	31	16½	31	10½
l	04$\overline{4}$5	V	04$\overline{4}$5:01$\overline{1}$1	2	96	46	97	7
A	04$\overline{4}$3	IV	04$\overline{4}$3:40$\overline{4}$3	a15	87	13	87	10
		IV	04$\overline{4}$3:01$\overline{1}$1	1	82	47	82	38½
		V	04$\overline{4}$3:01$\overline{1}$1	3	82	41⅓	82	38½
r	0.19.$\overline{19}$.13	II	0.19.$\overline{19}$.13:$\overline{19}$.0.19.13	10	90	45	90	44
		III	0.19.$\overline{19}$.13:$\overline{19}$.0.19.13	9	90	31½	90	44
		II	0.19.$\overline{19}$.13:01$\overline{1}$1	10	99	41½	99	51½
		III	0.19.$\overline{19}$.13:01$\overline{1}$1	9	99	49½	99	51½
f	02$\overline{2}$1	V	02$\overline{2}$1:01$\overline{1}$1	3	72	9⅓	72	17
E.	0.$\overline{13}$.13.4	I	0.$\overline{13}$.13.4:04$\overline{4}$1	4	148	27	148	28
Δ.	07$\overline{7}$2	V	07$\overline{7}$2:01$\overline{1}$1	1	118	34	118	27½
Σ.	0.11.$\overline{11}$.1	V	0.11.$\overline{11}$.1:01$\overline{1}$1	2	50	42	50	39½
v	21$\overline{3}$1	III	21$\overline{3}$1:2$\overline{3}$11	1	75	18	75	22
		V	21$\overline{3}$1:2$\overline{3}$11	1	75	15	75	22
		III	21$\overline{3}$1:3$\overline{1}$2$\overline{1}$	3	35	36	35	39
		V	21$\overline{3}$1:3$\overline{1}$2$\overline{1}$	1	35	43	35	39
		III	21$\overline{3}$1:12$\overline{3}$$\overline{1}$	1	47	17	47	1½
μ	54$\overline{9}$1	I	54$\overline{9}$1:5$\overline{9}$4$\overline{1}$	7	66	46½	66	42½
		I	54$\overline{9}$1:$\overline{9}$45$\overline{1}$	10	52	5½	52	11
		IV	54$\overline{9}$1:$\overline{9}$45$\overline{1}$	1	52	35	52	11
		I	54$\overline{9}$1:45$\overline{9}$$\overline{1}$	6	16	29	16	30
𝔘:	14.12.$\overline{26}$.5	III	14.12.$\overline{26}$.5:14.$\overline{26}$.12.5	2	63	10½	63	19
		III	14.12.$\overline{26}$.5:26.12.$\overline{14}$.5	4	53	38½	53	34
		III	14.12.$\overline{26}$.5:12.14.$\overline{26}$.$\overline{5}$	5	25	4½	25	46
		IV	14.12.$\overline{26}$.5:12.14.$\overline{26}$.$\overline{5}$	1	25	48	25	46
R:	8.4.$\overline{12}$.1	V	8.4.$\overline{12}$.1:12.4.$\overline{8}$.1	1	38	4	38	2
		V	8.4.$\overline{12}$.1:4.8.$\overline{12}$.$\overline{1}$	1	24	17	24	21
		V	8.4.$\overline{12}$.1:21$\overline{3}$1	1	15	37	15	30
q:	24$\overline{6}$1	II	24$\overline{6}$1:26$\overline{4}$1	3	80	1	80	1½
		II	24$\overline{6}$1:64$\overline{2}$1	5	37	21	37	30
		IV	24$\overline{6}$1:64$\overline{2}$1	1	37	38	37	30
		V	24$\overline{6}$1:64$\overline{2}$1	3	37	26	37	30
		II	24$\overline{6}$1:42$\overline{6}$1	9	30	48	30	39
		IV	24$\overline{6}$1:42$\overline{6}$1	2	30	41½	30	39
		V	42$\overline{6}$1:21$\overline{3}$1	1	31	42	31	49
c:	34$\overline{7}$2	V	34$\overline{7}$2:37$\overline{4}$2	2	65	34	65	24
		V	34$\overline{7}$2:43$\overline{7}$2	2	47	43	47	48½

aMeasurement made with contact goniometer.

Albite

Albite occurs incrusting orthoclase and hornblende of a previous generation often associated with calcite, secondary quartz and byssolite. The crystals are small, rarely exceeding 5 mm in length, clear and colorless with brilliantly reflecting faces. The strong twinning tendency gives rise to numerous striations and vicinal planes causing in every case a series of double images from the faces in the prismatic zone. The twinning is complex, in most cases combining the albite and pericline laws. A very common habit of albite twin is shown in figures 13a–13b, the faces illustrated being determined by approximate measurements, as no definite angle values could be obtained by reason of the complex twinning developed. Crystals of this habit occur notably associated with calcite of the crystal combination shown in figure 10b–10c. They are directly implanted on large hornblende masses of the first generation. A twinning habit shown in figure 14a–14b is found on the same specimen in small individuals buried in a mat of white fibrous amphibole which represents an advanced stage of the change from hornblende to byssolite. These rarely exceed 2 mm in length along the brachi axis and are detached and completely developed on all sides. They are milky white in color and penetrated with many inclusions of asbestic amphibole. In twinning they resemble the crystals from Roc Tourné, Savoy.[1] Both types of crystals show surfaces broken by numerous etch pits which correspond in symmetry with the twinning habit. The forms noted are b (010), c (001), m (110), M ($1\bar{1}0$), f (130), z ($1\bar{3}0$) x ($\bar{1}01$), y ($\bar{2}01$), n (021), p ($\bar{1}11$), and o ($1\bar{1}1$). Two doubtful negative quarter pyramids q ($\bar{3}52$) and r ($\bar{4}63$) in the zone [$\bar{1}11.\bar{1}30$] were noted as narrow faces but could not be substantiated from the material available. The planes of the hemiprisms (130) and ($1\bar{3}0$) are developed to an unusual habit for the species while those of the commoner hemiprisms (110) and ($1\bar{1}0$) are comparatively narrow though well defined. The reading on the measured angles in every instance varied materially from the theoretical value by a variable difference amounting in some instances to 30′ and due to the vicinal twinning according to the Pericline law.

Pyroxene

Pyroxene occurs as the variety augite in dark green to black crystals of prismatic habit associated with orthoclase and amphi-

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[1]Rose, G. Poggendorff's Annalen. 1865. p. 125, 457.

bole (hornblende) and always in close association with magnetite. Several crystals were obtained which measured 5 to 15 mm in diameter on the basal axes and 10 to 25 mm in vertical length. These were of a decided prismatic habit, elongated parallel to the c axis and showed, in the prismatic zone, a considerable development of the planes of the unit prism. The ortho, clino and basal pinacoids are present, the two former as narrow planes of medium brilliancy and the latter as a series of broad but dull and rough faces. The clinodome e (011) is also represented by a series of rough faces, from which, however, fair readings were obtained by using the method of a cemented cover glass. Well developed planes of the positive hemipyramid i ($\bar{2}$11) were noted on two of the largest crystals. Figures 15a–15b show a combination of this habit.

Natural etch figures were noted in the prismatic zone on prismatic and pinacoidal faces. Their arrangement, shape and relations to adjacent edges are shown in figure 16. On the planes of the clinopinacoid, these etch figures for the most part take the form of elongated rhombs, the long edges of which are parallel to the edges of the zone and the short edges of which are inclined toward the intersection 010: 011 making the acute angles of the rhombs 46°. In several instances a larger and shallower etch pit was noted on these planes having its sides parallel to the pinacoidal edges. Deep natural etchings occur on the faces of the orthopinacoid, the etch pits in general conforming to the symmetry required by the system. Two types of unsymmetric etch pits shown at b and c on the middle section of figure 16 are apparent exceptions to this general rule; it will, however, be readily seen that a combination of these two outlines produces a symmetric figure of the outline shown at a. Two types of etch pits occurring on the planes of the unit prism are shown at d and e. Both of these types are triangular in shape and are oriented with the long edges at an angle of about 8° with the zonal edges, as shown in the figure. The curved edges in both instances point away from the orthopinacoid and of the remaining straight edges those of type d lie parallel to the intersection 110: 001 and those of type e point toward the negative quadrants, the angles with the zonal edges being as indicated in figure 16. The etch figures show a marked tendency toward arrangement in lines along these latter edges, in the case of d these lines lying parallel to the plane of parting which may be assumed to have a direct influence on the shape of the triangles of type d.

The specific gravity agrees closely with that of augite giving for an average of several determinations on different crystals, G=3.331.

The extinction angle, as determined on a section cut parallel of o1o gave c C=54°. Thin sections show marked pleochroism as follows:

C = olive-green, $\mathfrak{b}$ = greenish yellow, $\boldsymbol{a}$ = bluish green.

Amphibole

Amphibole which is by far the most prominent mineral associated with the magnetite of Lyon Mountain, occurs in two varieties. Of these, a black hornblende occurring in immense crystals represents a phase of the same generation as the first generation of quartz previously described. The crystals of hornblende, which show the effects of partial resolution, are more or less corroded exhibiting rough and etched surfaces particularly on planes of the clinodomes. In some instances dendritic deposits of secondary stilbite were noted on the planes of the prismatic zone, a characteristic example of which is shown in plate 9. The following forms were observed: b (o1o), m (11o), e (13o), t (1o1), p ($\overline{1}$o1), r (o11), i (o31) and z ($\overline{1}$21). The habit is shown in figures 17a-17b. The reflections obtained from the faces were in most instances poor but the values of the measured angles corresponded with theory to a sufficient extent to admit of the identification of forms of such ordinary occurrence.

SUMMARY OF MEASURED AND CALCULATED ANGLES

Angle	Measured		Calculated		Angle	Measured		Calculated	
	°	′	°	′		°	′	°	′
$b{:}e$	32	20	32	11	$m'{:}z$	68	46	69	29
$b{:}m$	62	7½	62	5	$m'{:}r$	96	17	96	10½
$b{:}r$	74	15	74	14	$z{:}z'$	58	50	59	9½
$b{:}i$	50	19	49·	44	$p{:}r$	34	22	34	25
					$p{:}t$	55	0	55	4

Cleavage parallel to m is highly perfect, producing cleavage faces of remarkable brilliancy. The specific gravity is quite high

(G = 3.37) indicating a clearly marked hornblende. The extinction angle observed on a section cut parallel to 010 gave $c \wedge \mathbf{C}$ 30° 15'. Thin sections are highly pleochroic; $\boldsymbol{a}$ = yellowish green, $\mathbf{C}$ = greenish blue.

Thin sections of the wall rock show the derivation of hornblende from the augite previously described, the former mineral therefore taking rank as a secondary derivative. A subsequent change corresponding in generation to the calcite crystals of types III, IV and V has produced from the black hornblende a light green byssolite which in its advanced stages of metamorphism is reduced to a whitish, asbestic amphibole. A striking example of this first change is shown in the specimen depicted in plate 10 where the black hornblende is seen to terminate in feathery brushes of byssolite which latter mineral is accompanied by secondary albite derived from the primary orthoclase. The byssolite, in its color, properties and association resembles that from Knappenwand in the Tyrol. As near as could be determined the extinction angle measures $c \wedge \mathbf{C} = 15°$.

Zircon

Zircon is found in pegmatite in close proximity to the iron ore at the Parkhurst shaft, $1\frac{1}{2}$ miles east of the main workings at Lyon Mountain. The crystals which occur embedded in orthoclase and quartz range in size from 8 to .5 mm in diameter, the larger individuals invariably occurring in orthoclase. They are lilac-brown in color and vary in translucency from opaque in the larger specimens to translucent in the smaller ones, many of which show reddish by transmitted light. Many of the crystals show grayish zones symmetrically disposed on the terminations as indicated in figure 18b. The faces in the prismatic zone are sharp and brilliant and gave excellent reflections. In the zone [110.111] the planes of u and v are narrow and ill defined but, however, yield fair reflections and were established beyond question. The ditetragonal pyramid x (311) occurs only on the smaller crystals shown in figures 19a–19b, which were found embedded in quartz. In general these latter crystals were more brilliant and perfectly formed and yielded better reflections than the larger types represented in figures 18a–18b.

The results obtained from the measurements of eight of the best crystals are given below:

	Angle	Measured	Calculated		Angle	Measured	Calculated
		° ′	° ′			° ′	° ′
m:a	110:1̄10	45 1	45 0	p:p‴	111:1̄11	56 42	56 40
m:m′	110:1̄1̄0	90 1	90 0	u:u‴	331:3̄31	76 13	76 29
m:u	110:331	20 16	20 12½	a:x	110:311	31 50	31 43
m:v	110:221	29 5	28 54	a:p	110:111	61 38½	61 40
m:p	110:1̄11	47 43	47 50	x:xᵛ″	311:3̄11	32 45	32 57
p:p″	111:1̄11	84 25	84 20				
u:u″	331:3̄3̄1	139 35	140 35				
v:v″	221:2̄21	122 57	122 12				

Epidote

Epidote occurs in irregular strings scattered through the orthoclase of the pegmatitic phase of the wall rock and usually in close association with light gray massive wernerite. In several instances phenocrysts of amphibole in a wernerite matrix were noted which showed a distinct rim of epidote indicating a probable derivation of the latter mineral from a previously deposited amphibole. Measurable crystals were obtained from small veins, where they occurred deposited on a thin layer of bluish green marmolite and partially imbedded in massive calcite which constituted the ultimate vein filling. These crystals which average 3 mm in length show no unusual development in crystal forms or habit. Figures 20a–20b show this habit, to which all the crystals studied conformed with great regularity. The planes of the zone [100.001] are sharp and brilliant although frequently marred by vicinal striations. In many instances the crystals are somewhat bent. The planes of the hemipyramid n ($\bar{1}11$) are rough and dull while those of the prism u (210) although extremely small are well marked and bright. The following forms were noted: a (100), c (001), u (210), e (101), r ($\bar{1}01$) and n ($\bar{1}11$).

	Angle	Measured	Calculated		Angle	Measured	Calculated
		° ′	° ′			° ′	° ′
c:a	001:100	64 34	64 37	a:e	100:101	29 45	29 54
c:r	001:1̄01	63 34	63 42	n:n‴	111:1̄11	70 26	70 29
a:r	100:1̄01	52 11	51 41	u:u′	210:2̄10	109 7	109 1

Stilbite

Stilbite occurs abundantly in drusy crusts and aggregates of colorless transparent crystals and in yellow to brown sheafs, all of which display the characteristic pearly luster on the clinopinacoid. The planes of m (110), usual in the twinned parallel grouping of stilbite, are here replaced by those of the hemiorthodome f ($\overline{1}01$) which with the pinacoidal planes c (001) and b (010) produce a combination varying but slightly in shape from a right parallel-opiped, and which give to the parallel groupings a flat rather than a serrated aspect. This parallel grouping is shown in figure 21. The usual penetration twins with the twinning plane parallel to c are apparent in sections parallel to b in polarized light.

Biotite

Biotite in distinct crystals occurs imbedded in calcite of type I from a vug opening into the 600-foot level. The crystals average 20 mm in diameter and show fair development of the planes of μ ($\overline{1}11$) and b (010). A marked twinning habit with c for the composition face was noted in a number of instances, the arrangement of the crystals being that shown in figure 22. No accurate readings could be obtained in the reflection goniometer owing to the dull and irregular character of the faces, but sufficiently close measurements were reached with the contact goniometer to identify the forms b (010) and μ ($\overline{1}11$). A decided tapering toward the vertical termination due to "stepped" crystals in parallel position is characteristic of the occurrence. The crystals are black in color and only transparent in very thin plates. The interference figure in convergent light shows a small axial angle.

Titanite

Titanite of the variety lederite was obtained from the walls of the largest "vug" opening into the 600-foot level. The crystals which measured 3 to 15 mm on the b axis occur associated with orthoclase, magnetite and quartz of the first generation. They are dark brown to black in color and show brownish red in thin sections by transmitted light. A distinct parting parallel to η (221) gave a measured angle of 125° 35' corresponding to a calculated value $\eta \wedge \eta'$ 125° 42'. The prevailing crystal habit is shown in figures 23a–23b, although in one instance a considerable development of the planes of n (111) produced an elongation parallel to these planes which simulated a prismatic habit. The observed planes lie mostly

in the zone [001.110] and are, for the most part, brilliant and sharply defined.   Vicinal developments which were noted throughout this zone are probably due to the rounding of the edges characteristic of this variety.   Twinning parallel to a is common to this occurrence, the twinning habit producing sharply defined reentrant angles between c and c.   The forms observed with their measured and calculated angles are given below:

SUMMARY OF MEASURED AND CALCULATED ANGLES

	Form		Angle	Measured		Calculated	
				°	′	°	′
c	001						
a	110						
b	010						
m	110	$c{:}m$	001:110	65	16	65	30
		$m{:}m'''$	110:110	66	17	66	29
		$b{:}m$	010:110	56	46	56	46
n	111	$c{:}n$	001:111	38	4	38	16
		$n{:}n'$	111:111	43	25	43	49
η	221	$c{:}\eta$	001:221	49	7	49	15
		$\eta{:}\eta'$	221:221	54	25	54	18
t	111	$c'{:}t$	001:111	70	$17\frac{1}{2}$	70	23
		$t{:}t'$	111:111	68	53	69	9
l	112	$c'{:}l$	001:112	40	$25\frac{1}{2}$	40	34

Apatite

Apatite occurs quite abundantly both as a primary mineral associated with orthoclase and hornblende in large crystallizations, and as a secondary mineral, deposited from resolution of the former phase in small crystals associated with the calcite of types III, IV and V.   Both phases of apatite give distinct reactions for chlorine and fluorine.   The crystals of the first generation were obtained from the vug opening into the 600-foot level which furnished the large hornblende crystals previously described.   Like these, the crystals of apatite are in many instances of unusual size, the one shown in plate 11 measuring 7 cm in diameter while many of those lining the walls of the vug were considerably larger.   They show marked indications of an aqueo-igneous origin and were undoubtedly subjected to considerable mechanical stress when still in a plastic condition.   A striking evidence of this latter fact is given by the specimen shown   in plate 11.   In this instance heart-shaped

wedges of orthoclase have been driven into the perfectly formed apatite crystal causing a distinct inward curve of the surface around the edges of the puncture and a decided bulging of the material displaced by the injected wedge. The writer has produced a similar aspect in a prism of softened paraffin by gently pressing into its surface a steel wedge. The surfaces of the crystals show natural etchings corresponding in symmetry with the hexagonal pyramidal group. In general the apatite crystals of this phase resemble those from Natural Bridge and other localities in northern New York. The crystal faces do not admit of accurate measurements by reason of the rounded and uneven character of the surfaces. The forms m ($10\bar10$), x ($10\bar11$) and s ($11\bar21$) were identified with a contact goniometer.

Secondary apatite occurs in small bright crystals, perfectly transparent and light yellowish green to bluish green in color. The largest of these measured 6 mm in diameter. They show an apparent rounding at the termination which renders the determination of the crystal habit a matter of some difficulty. Fair reflections of the goniometer signal were obtained in all zones measured and the forms recorded were noted on all of the three crystals studied. The crystal habit as determined by the relative size of the reflecting surfaces is shown in figures 24a–24b. The following summary shows the results obtained from the measurement of three of the best developed of these crystals.

SUMMARY OF OCCURRING FORMS, MEASURED AND CALCULATED ANGLES

	Form	Angle	Measured (°)	Measured (′)	Calculated (°)	Calculated (′)
c	0001	$10\bar10:0001$	90	$2\frac{1}{2}$	90	0
m	$10\bar10$	$10\bar10:01\bar10$	60	0	60	0
a	$11\bar20$	$10\bar10:11\bar20$	30	0	30	0
r	$10\bar12$	$10\bar10:10\bar12$	67	12	67	1
x	$10\bar11$	$10\bar10:10\bar11$	49	42	49	42
		$10\bar10:01\bar11$	71	$8\frac{1}{2}$	71	8
		$01\bar11:\bar1101$	37	43	37	$44\frac{1}{2}$
y	$20\bar21$	$10\bar10:20\bar21$	30	38	30	31
w	$70\bar73$	$10\bar10:70\bar73$	26	$40\frac{1}{2}$	26	48
z	$30\bar31$	$10\bar10:30\bar31$	21	$25\frac{1}{3}$	21	27
s	$11\bar21$	$11\bar20:11\bar21$	34	$17\frac{1}{2}$	34	$14\frac{1}{2}$
		$10\bar10:11\bar21$	44	$18\frac{1}{2}$	44	17
μ	$21\bar31$	$10\bar10:21\bar31$	30	$19\frac{2}{3}$	30	20

GENERAL CONCLUSIONS

The occurrence at Lyon Mountain of two distinct phases of a mineral species, as has been noted in the cases of quartz, calcite, the feldspars, amphibole and apatite, points unquestionably to two distinct periods of mineral deposition. Of these, the first may be said to be characterized by the production of large crystallizations from an aqueo-igneous fusion, of which the superheated water acted as a powerful solvent. The marked prevalence of natural etched pits on the surface of the minerals of this phase, as well as their partial resolution bears evidence of the potency of this dissolving action. Considerable mechanical stress accompanied the formation of the minerals of this period and the evidence is not lacking that the perfectly formed minerals were still in a soft or pasty condition when subjected to external pressure.

The second stage of mineral production, which is marked by smaller and more perfectly crystallized individuals, was the result of recrystallization of the dissolved materials from the saturated aqueous solution, the dissolving action of which is apparent in the minerals of the first period. In some instances this second period may have been contemporary with the first, as in the case of the calcite of type I. In general, the minerals of secondary derivation are to be found incrusting those of the previous generation indicating a complete change in the mode of production.

Plate I

EXPLANATION OF PLATES

Plate I

1a

1b

2a

2b

3a

3b

4a

4b

Plate 2

Plate 2

Plate 3

Plate 3

9a

04$\bar{4}$3

11a

04$\bar{4}$5
22$\bar{4}$3
04$\bar{4}$3
11$\bar{2}$3
34$\bar{7}$2
01$\bar{7}$2
21$\bar{3}$1
24$\bar{6}$1
0·11·$\bar{11}$·1
8·4·$\bar{12}$·1

9b

21$\bar{3}$5
04$\bar{4}$3
21$\bar{3}$1
8·8·$\bar{16}$·3
40$\bar{4}$3

11b

04$\bar{4}$5
22$\bar{4}$3
04$\bar{4}$3
44$\bar{8}$3
01$\bar{7}$2
21$\bar{3}$1
34$\bar{7}$2
01$\bar{7}$2
8·4·$\bar{12}$·1
24$\bar{6}$1
0·11·$\bar{11}$·1
42$\bar{6}$1
4·8·$\bar{12}$·1

10b

10a

11$\bar{2}$3
22$\bar{4}$3
04$\bar{4}$3
14·12·$\bar{26}$·5
8·8·$\bar{16}$·3
34$\bar{7}$1
42$\bar{6}$1

10c

Plate 4

Plate 4

Forms of Type I   �ням
     "   "   II   ×
     "   "   III   +
     "   "   IV   ○
     "   "   V   ●

Plate 5

Plate 5

13a

14a

13b

14b

15a

16

15b

Plate 6

Plate 6

17a

17b

18a

18b

20b

20a

21

19a

19b

Plate 7

Plate 7

22 a

22 b

23 a

23 b

23 c

24 a

24 b

Plate 8

Secondary quartz from Lyon Mountain showing occurrence of secondary hematite in shotlike hemispheres and circular disks. The scale is divided into centimeters.

Plate 8

Plate 9

Amphibole (hornblende) from Lyon Mountain showing dendritic deposit of stilbite on planes in the prismatic zone. The specimen is reproduced in natural size.

Plate 9
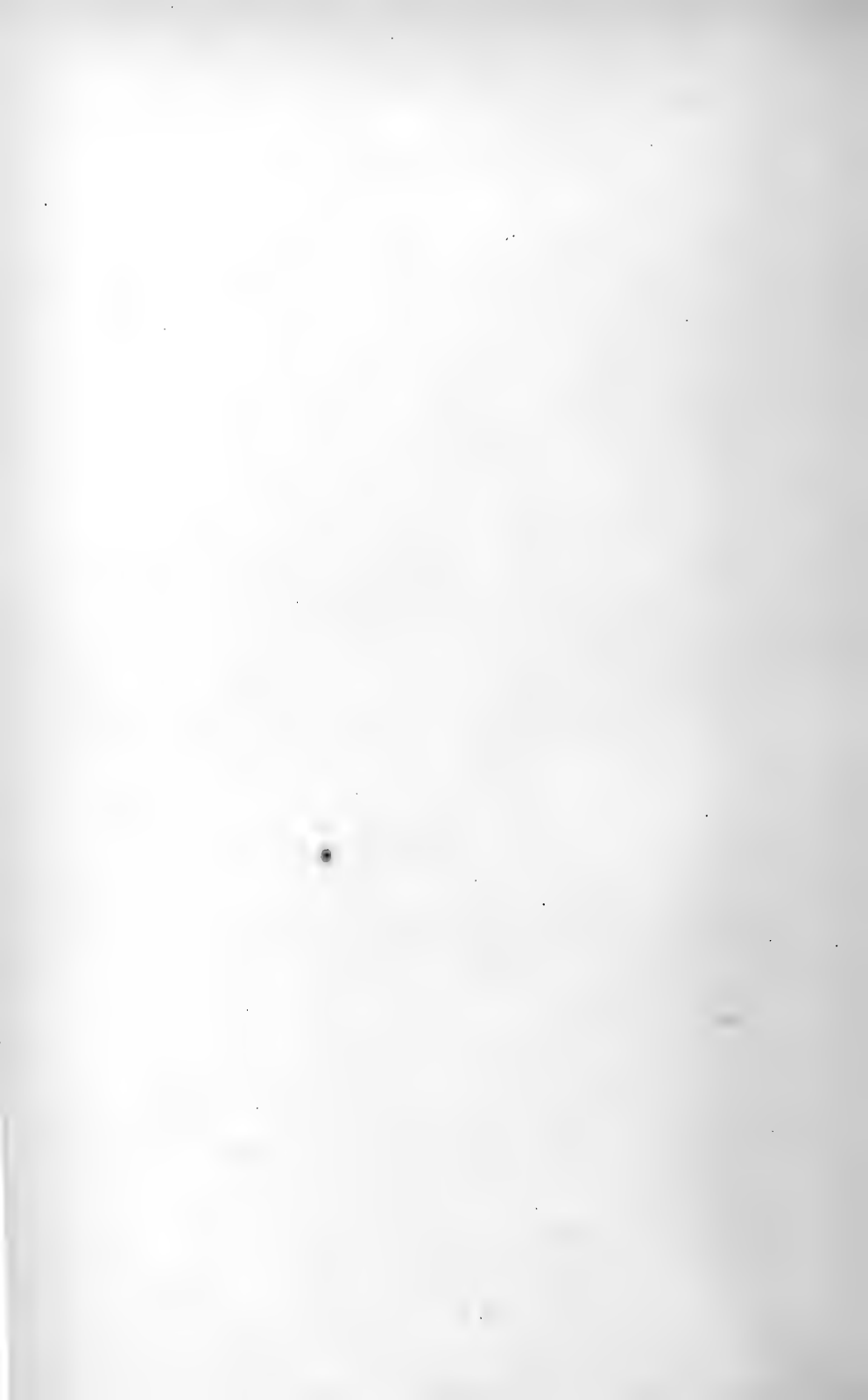
Plate 10

Amphibole and quartz from Lyon Mountain showing transition stage from hornblende of the first generation to byssolite of the second and also the crust of secondary albite and stilbite on the primary minerals. The scale is divided into centimeters.

Plate 10
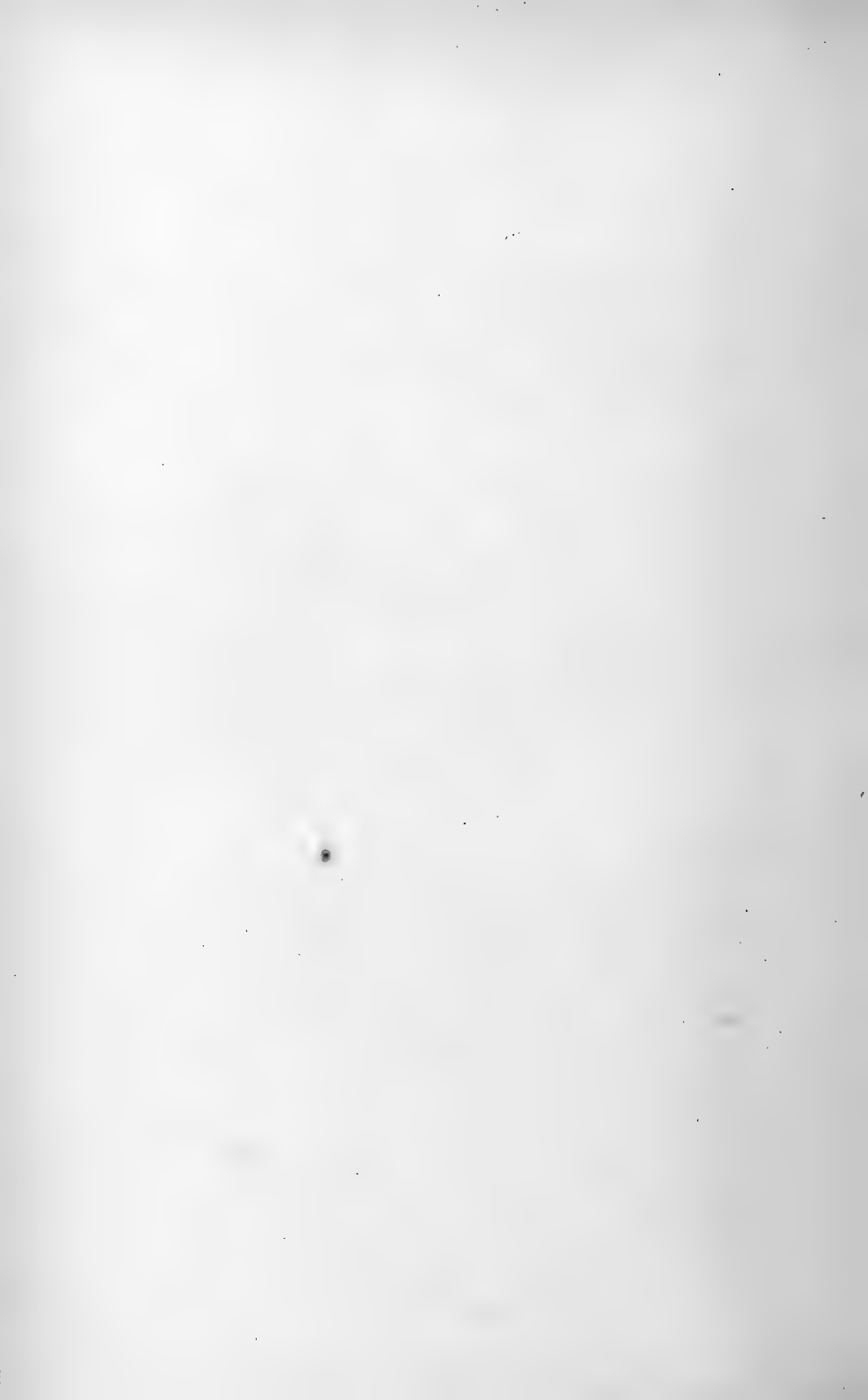
Plate 11

Crystals of apatite of the first generation in pegmatite, from Lyon Mountain, showing a wedge of orthoclase driven into the side of the crystals by external force. The orthoclase fragment appears as a heart-shaped spot near the upper edge of the specimen. Note the bulging of the edge of the crystal around the fragment. The scale is divided into centimeters.

Plate 11
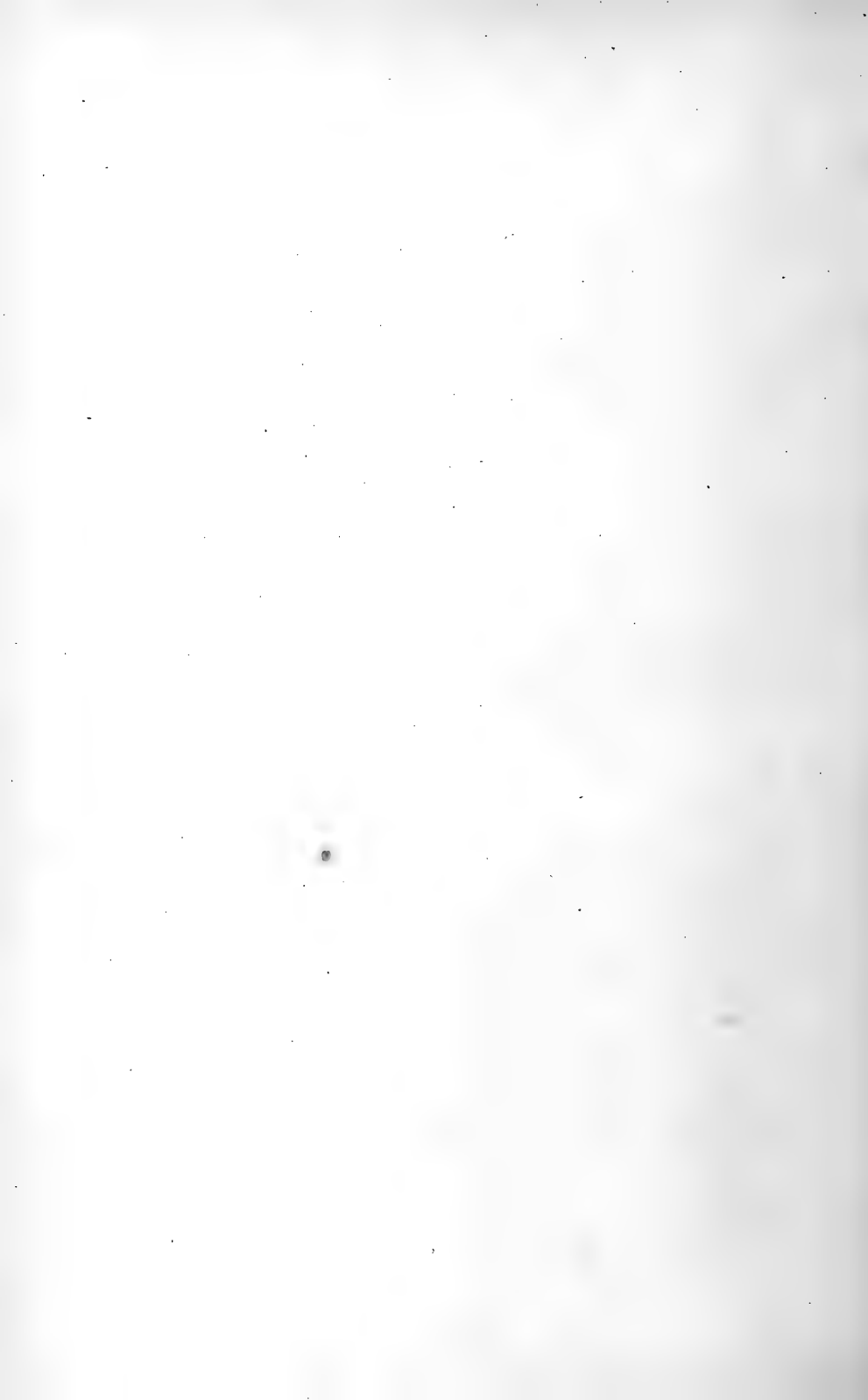
ON SOME PELMATOZOA FROM THE CHAZY LIME-STONE OF NEW YORK

BY

GEORGE HENRY HUDSON

In some material from Valcour island, Lake Champlain, given by me to Mr Percy E. Raymond in 1902 he was so fortunate as to find a fragment of B l a s t i d o c r i n u s c a r c h a r i a e - d e n s Bill. with two of the large deltoid interambulacral plates in position and showing much of the internal structure of an ambulacrum [pl. 5 fig. j]. In 1903, while examining some exca- vated material from the same locality (which the writer had left out to weather), Dr C. E. Beecher found a small fragment of a crushed individual which showed a pair of the plates I have called bibrachials, nearly in their proper relation to the great deltoids. In 1904 the writer found two bibrachials joined along their common suture, and these are figured on plate 4 at L. While gathering up some of the remaining portions of the same weathered stratum in 1905, Erastus M. Hudson obtained the most complete specimen of this species yet found. From this material and from about a thousand separate plates kindly assembled for me by Miss Ada M. Carpenter from the unas- sorted collections of some years, and representing over 186 different individuals, as shown by that number of apical pieces, I have made the following more complete description of this interesting species.

Blastoidocrinus carchariaedens Billings

Can. Org. Rem. Decade IV. 1859. p. 18, pl. 1, fig. 1a-1s

Plates 1-7, text figures 1-3

General description. Theca large, in some specimens attaining a hight of 36 mm and a width of more than 40 mm, pentagonal, clearly separated into an oral and aboral surface with the greatest width at the boundary.

Aboral portion of theca deeply invaginated, appearing in a side view as a low, inverted, truncate cone whose outer walls

make an angle of 58° with the vertical; the ratio of the length of these outer walls to the distance across the invaginated area in a specimen a little more than half grown is as 11 to 9, in older specimens the difference is greater.

The oral portion, when the high ambulacral ridges and anal piece are in position, is four times as high as the aboral and rises from it as a dome, maintaining a vertical outline for nearly one third its hight.

The published restorations of this species have been made from fragments showing but very little of the aboral portion and with the ambulacral ridges and anal piece broken from the oral surface. These figures give the aboral portion nearly twice the hight of the oral while in reality the oral has very nearly four times the hight of the aboral. A side view of this species seems therefore to be more strongly suggestive of Pentremites than Mr Billings supposed.

The plates of the aboral surface, while nearly 80 in number, are arranged in four horizontal circlets. The first two are of basals and radials as in crinoids. The plates of the third circlet consist of 10 bibrachials and 13 interbrachials. The plates of the fourth circlet are between 50 and 60 in number but while the alinement is horizontal and not zigzag, the circlet is cut at each radius by the upward extension of the bibrachials.

The radials are so remarkably like the basals of certain Rhodocrinidae and are so abundant in Chazy deposits that it has seemed best to describe them rather more fully than is usual.

Basals. Basals unknown but probably very small and together having but little greater area than a joint of the stem. The " basals " of E. Billings, of which he says " from another specimen it appears that there are at least three, if not four or five, basal plates, and their form is remarkable," are not basals but radials. All published statements concerning the basals have been made on the authority of the quoted passage and are without value.

Radials. Radials five, many angled; each having two (?) proximal very short sides resting against the basals; two long sides where each plate meets its neighbor in this circlet; next above this on the left is a side which supports the largest plate of a lower row of two or three interbrachials; on the right are either two or three sides meeting the whole lower row of interbrachials; the remaining two sides, which are distal, support the bibrachials.
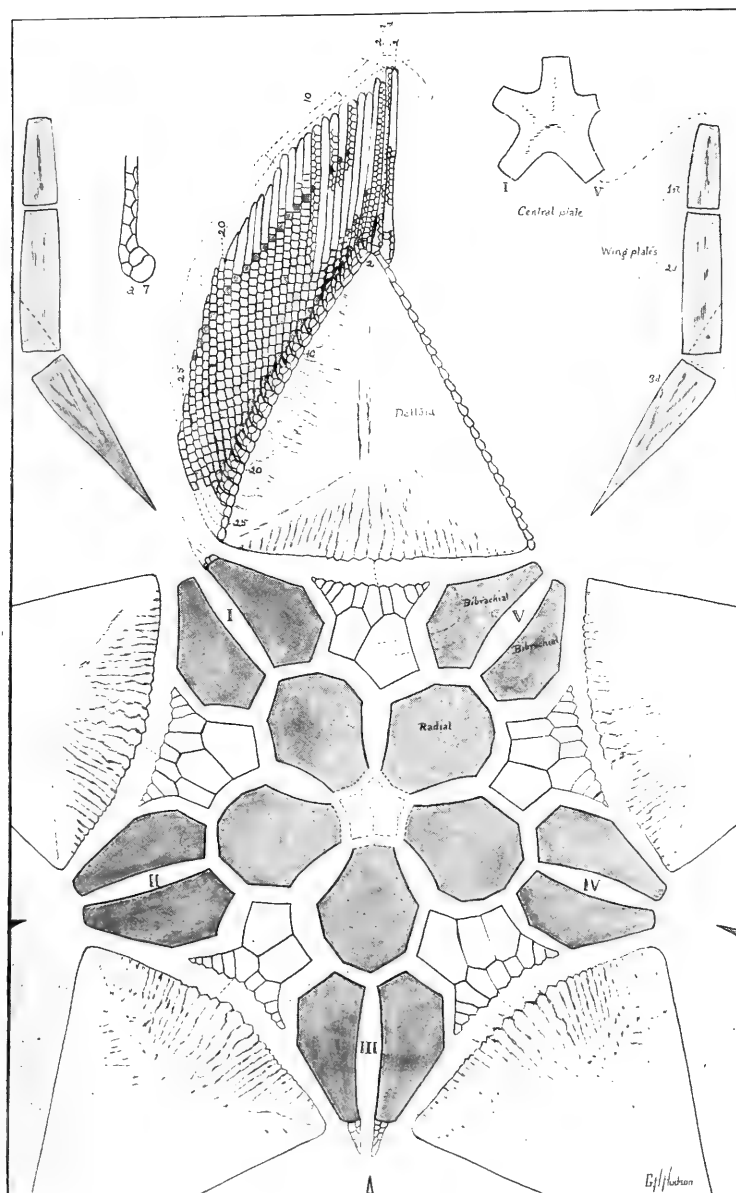
Fig. 1   Analysis of the theca of B l a s t o i d o c r i n u s   c a r c h a r i a e d e n s.   The bra-
chioles have been drawn for one side of one of the deltoids and all their external ossicles out-
lined save a portion of those between the 1st and the 10th and the tips of the 11th to the 18th.
The 6th external ossicles have been shaded as have also the 10th, 14th and 22d ossicles of the
uniserial brachioles.   At a7 the lower ossicles of the 7th brachiole have been drawn to a
larger scale.   The wing plates of but two of the radii are shown.   The piece marked "central
plate" is the apical piece.

The radials are thus seen to be unsymmetrical, supporting one or two more plates on their right sides than on their left. This has turned the apex of each plate to the left and through the bibrachials has moved the distal or outer end of each ambulacrum from 7 to 10 degrees from its expected position, as is shown in plate 1, lower figure. The center of this figure was found by extending inwardly the lines marking the suture between each pair of radials. The position of these lines extended outwardly is marked on the circle nearly surrounding the figure.

The proximal portions of the radials are gradually bent upward [pl. 4. k] to form an angle of 90 degrees with a line across the base of the theca. They thus together form a deep conical pit or crater whose outer rim is a little more than twice the diameter of the stem but which gradually becomes narrower as it penetrates the theca and brings the thin, inner portions of the plates against the stem at a depth of seven or more of the stem rings. The outer or distal portion of the radials is bent upward at an angle of 30 degrees with the line across the edge of the crater and this portion of the plate (one third or less of its length) is from 1 to 2 mm in thickness at the suture or from three to six times the thickness of the edge next the basals. An exception to this thickness is made where the radial meets the smallest interbrachial plate of the lower row; here the thickness at the edge is markedly reduced, as shown in plate 4 at i.

Each plate shows a raised central mound on the rim of the crater, carrying this rim outward a little and giving it a somewhat pentagonal figure. From this mound, or just above it, there radiate some 10 or 20 depressed grooves, the more nearly transverse ones being the deeper and together making a marked transverse depression a little below the apex of each plate. The more marked of these lines run across the suture and either across or between the lower line of interradials. The portion of the plate forming the inside of the crater is ornamented by some fine rounded labyrinthine ridges as in plate 4, g, or a dewdrop pattern as at h. The inside surface of these plates is smooth with sometimes a raised central, longitudinal ridge at the bend; probably representing attachment of viscera [pl. 4, i and j]. The largest radial so far found measures 10.48 mm across at greatest diameter or very nearly twice the diameter of the radials of the specimen figured in plates 1, 2 and 3. This plate [pl. 4, a] shows less ornamentation than the others but the radials seem to vary rather markedly in this respect. Fig-

ure c on the same plate shows rather clearly a series of growth lines, or rather rest lines, where periodic pauses seem to have been made in addition to the edge of the plate.

The resemblance of these plates to the basals of certain Rhodocrinidae (especially to those genera with concave bases and two or more interradial plates over the no longer truncate upper edge of the radial) lies in their approximate size, the bent condition, the thinner proximal portion, the radiating ridges on the distal surface, the depressed apex, the occasional visceral ridge [*see* text fig. 8] and the more than usual number of angles. In the Rhodocrinidae, however, the distal ornamented area is usually much greater than the bent proximal area. The plates once recognized are easily separated from all others.

Bibrachials. In each radius of the third circlet is a pair of usually hexagonal plates each about one and one third times as long as the greater width of the radials and a little less than half as wide as they are long. The bibrachials meet over the apex of a radial in one long, straight suture and their narrow (sometimes rather pointed) distal ends reach the boundary of the oral surface and together support the end plates of an ambulacrum and usually four very short brachioles. The outer edge of each plate has three sides; the two lower meet the end plates of the two rows of interbrachials and the remaining side meets the horizontal outer third of the base of one of the great deltoids and thus also reaches the oral boundary.

The outside of the plate is ornamented with transverse, fold-like, rather rough ridges which become less prominent and disappear as they reach the long common suture of the two plates. The inside surface is smooth. The face of the common suture is very smooth and near the middle of the plate this suture occupies half its width, the plates together making a very strong element of the theca. The outer suture is crossed by numerous grooves which, at least on the upper half, mark the position of the pores or slits on the deltoid through which water passes from the hydrospires to the exterior. These features may be seen in figures l, m and n, on plate 4. The number of external, transverse ridges and the number of grooves across the outer suture will depend on the age of the plate as we shall see under the description of the deltoids.

These plates have been called *bibrachials* without any intention of signifying that they are homologous with the brachials of crinoids. They support the distal, not the proximal end of

an arm.   The first and second circlet of similar forms have however received crinoid terminology and I have used similar terms for the plates of the third and fourth circlets.   These last circlets lie in the brachial region of crinoids.   The bibrachials here follow the radial as if that were a primaxil and the pair suggest the II Br$_1$ of crinoids with their long axes placed vertically instead of horizontally.   I do not mean to lead the reader to conclude that I have considered these plates as divided radials though a comparison with the higher blastids might hastily lead one to that conclusion.   Three other hypotheses suggest themselves which may be here given without comment.   These plates may be homologous with the cystidean pair of plates that would very naturally lie over what became a radial (through reduction of number and acquisition of pentamerous symmetry), possess a vertical common suture and become modified on being reached by the extending oral food grooves.   That is, these plates may be considered strictly interradial and without radial elements between them.   In this case they are but specialized plates similar in origin to the other plates of the third circlet. The double character of these plates and their position at the end of a long double row of highly specialized adambulacrals might lead us to adopt the hypothesis that they were derived from the outermost adambulacrals of such a form as Protero-blastus on which a more distinct differentiation into oral and aboral surfaces had been impressed together with loss of function at the aboral end of the arm.   A third hypothesis, and one perhaps more suggestive than the last, would be to look on these bibrachials as true interambulacrals thrust from the oral surface and to their present radial position by the great development of the deltoids but still bearing brachioles and outward markings indicating a former respiratory function.

Interbrachials.   In each interradius there are two or three interbrachials of the third circlet, one much larger than the other, and from 10 to 12 smaller plates of the fourth circlet.   The upper ends of the latter are each in contact with the middle part of the great deltoid above.   They no doubt once functioned as respiratory plates and to a certain extent they may still do so though any such present function is unknown.   The arrangement, shape and relative size of these plates is shown in figure 1 of the text as is also their contact with the bibrachials and radials.   Plates 2 and 3 show four different groups of these interbrachial plates

in position.   These plates complete the aboral surface of the theca.

Deltoids.   Perhaps the most remarkable structures of the oral surface are the great deltoids—large triangular plates, each of which has come to occupy an entire interambulacral area.   The superficial resemblance of these plates to "sharks' teeth" evidently suggested the specific name, and such plates have induced local collectors to stoutly maintain that "big fish" existed in Chazy time.

These interambulacral plates have the middle basal portion strongly bent inward and the lateral portions rather markedly outward; a vertical section of one such plate would thus be convex outwardly and a transverse section concave outwardly. The two upper or lateral sides of each plate support on each edge from 6 (or less) to 40 (or more) brachioles with their corresponding adambulacral or flooring plates.

Each bordering brachiole (with the possible exception of one of the apical pair) is connected, by a pore or slit *between* the adambulacrals, with a vertical or rather a longitudinal groove on the inner surface of the deltoid.   From both sides of this groove there extends a remarkably thin respiratory sheet, slightly bent away from its fellow soon after its origin and usually still more so near its inner margin where the edges meet in a rounded roof and form a lamellar cavity through which was maintained a flow of sea water which made its exit at a short slit at the base of the deltoid.   This row of basal slits, one for each hydrospire, is very clearly shown in plate 5 at j. This figure is reduced from a photographic enlargement and as the slits did not appear as dark as in the specimen, the seven outer ones were darkened with india ink; the remaining slits have been reproduced without retouching of any kind.   The bibrachial shown in the figure had been moved slightly inward from its natural position and the specimen thus shows the water exits to better advantage.   The arrangement of these hydrospires on the plate may be seen in figure 2 which is from a camera lucida drawing of a cross-section of the right posterolateral interradial deltoid made at, or just below the 17th brachiole and which shows 34 hydrospires.

The most rapid increase of growth of the deltoid was at the two lower angles where new brachioles were regularly added at the side of and just below the last formed, until the number became perhaps as many as 50 on a side, giving a probable total

of 500 brachioles to some old specimens. With each added brachiole there was also added a very short, rudimentary hydrospire consisting at first of a membranous fold open externally. As the hydrospires with their grooves are no farther apart in adult specimens than in young ones [*see* pl. 5 fig. k-o of inner surface of deltoids, where approximately 14 grooves lie side by side in a width of 5 mm whether young or old plates are taken] it follows that direct lateral growth was limited to the widening of the plate by the addition of these new brachioles and their hydrospires.

Direct upward extension of the hydrospire and the portion of the plate bearing it would soon bring the base of any one brachiole up to the level of the former position of its next older companion while the companion constantly maintained its former superior relation by a similar upward extension of its own hydrospire and plate portion. Thus the plate was indirectly widened by upward growth of the portions consecutively added at the lower angles. This upward extension in the early stages of the development of the plate was no doubt as rapid as the extension of the lower angles, but at a later stage the lower angle extension was the more rapid.

The rather remarkable parallelism of the hydrospires would show that the basal plates of a young brachiole ceased to grow as soon as a subsequent brachiole was added. That there was a slight enlargement of the later formed brachioles is however shown in plate 5, figure o, where the grooves of the hydrospire, between 30 and 39, begin to show a very appreciable change in direction. Another fragment not figured shows a still greater extension of this angle of a plate and a change in the direction of the grooves of more than 45 degrees. It is on this bit of evidence that I have suggested that the 39 side grooves of plate 5, figure o, may have been surpassed in this specimen by at least 11 others. Its possessor must have shown a more remarkably starfishlike form, when viewed axially than the specimen figured in plate 1. It must also have brought the ends of its ambulacra more nearly down to a level with its base.

The hydrospires and their plate portions were also extended downward and the points of their origin became thus left along a line still visible on the external surface of the plate and connecting the older central portion with the newer extension of the angles. This line may be seen in plates 1, 2 and 3, and is also clearly shown in plate 5, figure j. This downward exten-
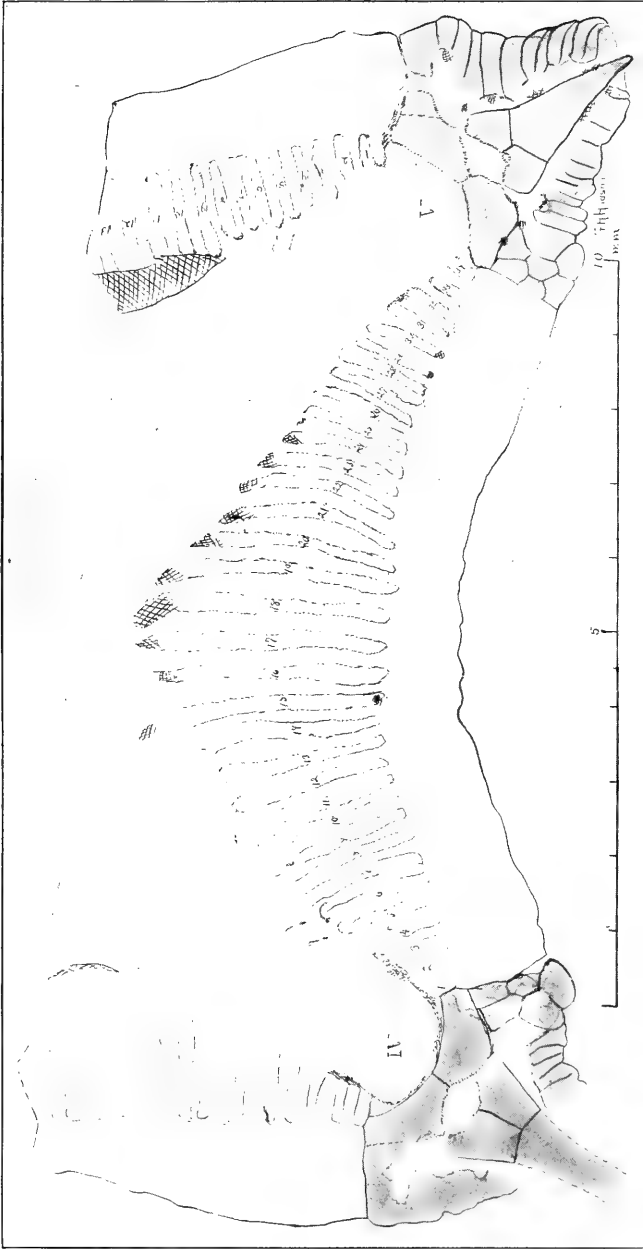
Fig. 2 Camera lucida drawing of a transverse section through a deltoid and two ambulacra of B. carchariaedens. The position of the section is indicated in plate 3. The ambulacral elements are shaded and surround unshaded areas where the section transmitted much light. The cross hatching indicates the position of internal deposits of a very fine yellowish sand or clay, the finer stippling indicates carbonaceous deposits. Four arrows point to detached inner edges of hydrospires. The 15th hydrospire has also lost its inner edge as indicated by the falling in of its load of the yellowish earthy deposit. The heavy deposit of this material resting against the shorter hydrospires near the upper right-hand corner probably represents a partially filled intestine.

sion of the plate was not so rapid as its upward. It required also the gradual filling in of the older position of the hydrospire slit or pore. The filled in material did not reach the outer surface of the plate and the external furrows thus lie directly over the internal grooves. That the filled in portion was the weaker and more readily dissolved in weathering seems to be shown by the widening of the slits of the lower margin in all plates found in a detached condition. This widening is shown in the figures of plate 5 save in the fragment protected by its bibrachial at j.

During the downward extension of the older hydrospires there appears to have been a widening of their bases to correspond with an increase of function. This was accompanied not only by the inward bending of the plate toward the center of the theca, of which it may have been in part the cause, but also by the throwing of the outer ridges between the slits into a marked zigzag and giving them a still stronger external thickening near the suture.

There was no marked thickening of the plate after the addition of new sheets of stereom at the edges. Young plates are somewhat thinner than the old plates but the latter are thinner near their centers. The structure of the ambulacrum, having at least in places, four plates in a line across the edge of the deltoid, necessitated a rather thick sutural face for even young plates. This thickness was gradually increased at the lateral edges of the plate as is shown by figure 2.

The increased growth at both ends of the hydrospires and the thickening of the plate was accompanied by increased growth in depth of the hydrospire membrane; the oldest portions or that under its place of origin becoming the deepest, hanging far into the coelomic cavity, and giving a triangular outline to the structure when viewed from the side. To enable them to make this continued growth these structures must have had their inner edges remain membranous. No primary calcification is apparent in the cross-section, their outlines being seen only as a fine, rather interrupted line of carbon particles. The portions of the membrane next the plate became strengthened by the deposit of calcareous matter, but the whole structure was so delicate as to be rarely preserved. Plate 5, figure n, has a small area showing the outer edges of these thin hydrospires still attached to the plate. Another fragment of a deltoid shows them in a still more perfect state of preservation but so filled in with rock deposit as to show but little in a photographic

enlargement and it is therefore not figured.   Under the micro-
scope the specimen shows the walls of the hydrospires to consist
of irregularly thickened and corrugated sheets so constructed
as to give strength with use of very little material and so secure
the thinness necessary for the exchange of gases with the sea
water.   The slight bending of the inner ends of the older hydro-
spires in figure 2, the loss of the inner edges of several of the
larger and the detached and shifted edges of others, indicated
by arrows, all point to their membranous character and their
tearing during decay.

The addition of brachioles and hydrospires while consecutive
was broken by periods of rest, and " growth lines " so formed
may clearly be seen in plate 5, figures h and i, the older deltoids
being easily recognized within their newer margins.

The younger, thinner deltoids show vertical grooves on their
upper surfaces which lie over the hydrospire grooves below.
The thicker additions made to the edge of the plate by the
upward growth of the newer brachioles soon mask their external
parallelism and give rise to a series of external ridges running
at right angles from the lateral plate margins.

It would seem that young plates having but 12 hydrospires
could hardly have had any portion of their bases supported by
the bibrachials.   The interbrachial plates alone would support
the lower edge of the deltoid and the form viewed axially would
be simply pentagonal, without the asteroidlike projections, or
as in Troostocrinus.

The increase in width of the deltoid would be accompanied by
increase in length of the bibrachials.   Their peculiar form is
thus in part brought about by the greater growth at their
distal ends.   It may be noted that this extension has constantly
carried the distal end of an ambulacrum farther away from its
radial plate.   Earlier stages in development would show that
closer proximity possessed by its ancestral forms and from
which the Eublastoidea with their notched radials took a diver-
gent line.

A comparison with Codaster leads one to the conclusion that
the deltoids, in their origin, were true deltoids or orals.

I may have asserted rather too positively that the hydrospires
lie in the grooves on the inside of the plate.   In the cross-section
of the deltoid the boundary between the coelomic cavities and
the plate could not be readily made out.   The outer ends of the
hydrospires are clearly marked by carbonized lines convex out-

wardly. These are without doubt very near the inner boundary of the plate. There exist in this cross-section more faint and diffuse lines of scattered carbon particles that connect these outer ends of the hydrospires with each other and where the lines can be distinguished they seem to lie on the whole a little nearer the exterior of the plate. This gives one the impression that the hydrospires rested on the internal ridges rather than in the grooves. The fact that the basal hydrospire slits open directly into the grooves seemed to me to negative such a conclusion. The weaker carbonized lines probably do not mark the inner boundary of the plate but show the outer folds of the membrane forming the hydrospires. If we imagine a series of folds formed as in figure 3 of the text with their outer edges
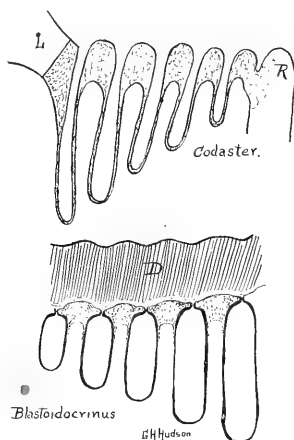
Fig. 3   A diagram of the hydrospires of Codaster copied from F. A. Bather's The Echinoderma [part III of A Treatise on Zoology edited by E. Ray Lancaster] p. 83, and a hypothetical diagram to show probable manner of formation of the hydrospires in Blastoidocrinus.

thrown very closely together and adhering in part before stereom formation took place and if we further suppose that stereom was formed more abundantly at the outer folds as in Troostocrinus and Codaster, while at the same time the outside was covered by the thick stereom built above the fold along that wide face of the deltoid supporting the four rows of plates before mentioned; then we shall find a condition of things not only as shown in figure 3 but also actually existing in figures k, l, m, n and o of plate 5 where the ridges are seen to be narrower across their upper edges than the distance across the groove at the same level.

The inner surface of a deltoid is not often seen in as perfect state of preservation as in the material photographed for these plates. The dark calcite, showing the presence of carbon, does not seem to weather so rapidly as pure calcite. This differential weathering has often left the plates in great perfection. The extra deposit of carbon then at the outer closed edge of the hydrospire fold should tend to preserve it, while the less carbonized filled in ridges between the hydrospire folds and representing the inward thickening of the outer fold would be more rapidly dissolved away and thus leave the more uniform smoother condition usually found. If this idea of the plate extension be correct the stereom of the plate can hardly be said to be folded. The advantage of closing the outer slit of the fold save at its extreme ends will be manifest and the flow secured by connection with the food groove of a brachiole gives us a very effective organ of respiration. Reduced to their lowest terms these hydrospires seem to be diplopores added to a plate through an inward fold of ectoderm and coelomic epithelium at a suture and bridged over across the outer middle of the opening to form a sac with two external openings or pores. In true diplopores there was no extension of the sac and the openings soon became included by the continued growth of the plate around them. In pectinirhombs the fold crossed the suture, a probable extension of the membranes occurred and therefore a separation of the pores through plate growth, the extending lines still indicated at the surface as in Pleurocystis, or obliterated as in Schizocystis. Hydropores of the form of Blastoidocrinus seem to be derived from the diplopore type from plates supporting brachioles and thus coming to be associated with the power to maintain a marked flow of water, in which case the neglect to follow the established and inherited rule to close the plate around the pore would be a " weakness " tending to insure survival and the pores would thus come to lie at opposite margins of the plate.

Brachioles. The brachioles start out at nearly right angles to the edge of the deltoid but at the sixth external plate [the first row shaded or darkened in fig. 1] the brachiole assumes a nearly vertical position. The brachioles at the apex are the oldest on the deltoid and are also the longest, being 6 mm long in the specimen figured, and thus as long as one fourth of the extreme hight of the specimen. These oldest brachioles and some six to eight others on each side of them show on their outer surfaces two rows of alternating plates some 60 in number.

Farther out on the ambulacrum the brachioles possess this outer biserial arrangement between the first and the eighth but after this are uniserial. The larger drawing of the seventh brachiole at a in figure 1 shows a transitional form. These newer brachioles show from 17 to 30 external plates. Each brachiole, with the exception of the two oldest, starts with a single large kidney-shaped plate very slightly less than .5 mm in longest diameter. This is surmounted by two plates in which the lower or distal is much the smaller; the next two plates above this are of nearly equal size and of the pair that follows these it is the upper or the one nearest the axis of the theca that is the smaller. It appears as if the outer smaller plate of the first pair became the foundation plate of the arm. The law of biogenesis would indicate that biserial brachioles preceded the uniserial but the change in this instance may be caused by a rotation of the brachiole to the left on its own longitudinal axis, as is indicated at A7 figure 1 and by other earlier brachioles of this specimen, bringing the left-hand plates of a biserial arm to the front and making the arm appear uniserial. The diagonal sections of the lower brachioles in figure 2 show in places a section through a pair of plates and the structure near the base of the brachioles suggests the arrangement of the side plates and outer side plates of Codaster.

Where the upper brachioles have been turned away from the wing plates, as shown in plate 3, lower figure, at a, the older brachioles seem to have had an additional row of plates on either side and alternating with the outer or back plates. A cross-section of one of these brachials would give the form of a parallelogram with its long axis set at right angles to the surface of the wing plate. The middle two fourths of the rear wall consist of a double row of very small, alternating, covering pieces. The cross-section of the lower parts of the newer brachioles seems to show only the back or outer plates (the end of but one of them seen from the outside) with greatly elongated sides and with traces here and there of what may be small covering plates.

One brachiole in the anal interradius seems to have been certainly free from the others for its entire length but the brachioles with apparently uniserial back plates have their margins zigzagged as if they had become bound, each to its neighbor, at their sides. This may not have been true of all the upper brachioles but where some of the older ones have fallen away from the wing plate, as in plate 3, lower figure;

the evidence seems to favor the idea that these brachioles swung out as one continuous sheet and that the outer edge of this sheet was subsequently broken away. This feature reminds one of the arm of Cleiocrinus, a species of which I have found in the same bed with Blastoidocrinus, and is another good example of homoplasy. How much of the base of this sheet could leave the internal plates of an ambulacrum is another question. It seems to have been fixed at least up so far as the eighth row of back plates.

There remain for description some brachioles apparently four in number, attached not to the deltoid but to the upper ends of each pair of bibrachials. These appear to be biserial, and are so at least in part, but they are small and tapering and the arrangement of these plates is made out with exceeding difficulty. The inner two are still more tapering and rudimentary in character. They also possess no perfected hydrospires for the bibrachials are destitute of any such structure. Are these *old* brachioles remaining attached to a plate that once possessed a hydrospire system or are they new brachioles in the building? If old, then the new brachioles must be formed between the more mature outer ones and the last brachiole on the deltoid; if new, they must be constantly pushed to the side by still newer additions and one by one take their places on the deltoid. There is no evidence to show brachiole formation between these and the deltoid but these grade very regularly into the more mature forms and there are a number of brachioles with their basal single plates still half on the bibrachial and half on the deltoid. The fact, already mentioned, that these lowest plates make practically no increase in size after being given a position on the deltoid, is of itself significant in this connection.

Adambulacrals. Between the deltoids the coelomic cavity is completely roofed over by an arched wall, concave inwardly, consisting of a double row of alternating (?) adambulacrals. These plates, seen from the side, are somewhat in the form of a parallelogram with the longitudinal axis about twice as long as the transverse axis. The two long sides are slightly but very regularly convex toward each other; each of the two ends bears four obtuse angles. The middle face of the outer end rests against the inner edge of a deltoid; the face below this sinks into the coelomic cavity and is parallel to the short side of the brachial end of a hydrospire; the outer face of the same

end rests against one or more small plates apparently forming
a double row down the middle of the edge of the deltoid and
just inside of the apparently single kidney-shaped foundation
plates of the brachioles. These small plates, with probably
some others, serve to floor a rather large brachiolar cavity which
is represented in figure 2 by shading its boundaries. The sec-
tion, which is rather thick, admits much light over this area and
thus suggests a series of connected brood chambers. The
boundary plates of this cavity require further study. The inner
end of an adambulacrum has one face against a covering plate,
a middle concave portion bounding nearly a fourth of a circular
food groove, and an inner or lower face that abuts against the
opposite row of adambulacrals.

Between each plate and its neighbor in the same row there
are two openings, one into the food groove along the line of
juncture of the upper, inner faces of the plates and one into a
hydrospire along the line of juncture at their outer or deltoid
edges. The plate is grooved from the middle of the longer
concave upper surface toward the food pore on one side and
again from the same middle portion toward the hydropore (?)
on the other side. This gives the appearance of a little twist
to this outer long edge of the plate and shows that the brachiolar
chambers along the side of an ambulacrum were probably con-
nected with each other. The older plates retained the power
of extension of their stereom and the upper figure of plate 1 will
show that the older became the larger and very materially wid-
ened the ambulacrum. These plates rather strongly suggest
the ambulacral plates of Asterias.

There is no trace of a lancet plate and perhaps the question
of homogenesis of bibrachials and lancet plates is worth con-
sidering. Our species has little to offer, but its bibrachials
partly separate the deltoids and reach the primary meristem of
a ray at one end, while the other abuts against the apex of a
radial. This is closely the position of the lancet plate in
Codaster. The lancet plate of Eleutherocrinus with its seem-
ingly double oral ends would suggest that possibly the primitive
lancet plate was double.

Covering plates. The covering plates of an ambulacrum are
remarkably large and heavy. Each is as wide as the adambula-
cral directly over which it rests and its thickness is extraordinary.
The outer or side surfaces of a row are slightly concave and very
smooth; against these surfaces rests a portion of the brachioles.

The upper surfaces of some of these plates may be seen in plate 1, upper figure, and an impression of these surfaces in plate 6, figures k and l.

Wing plates. Along the center of each ambulacrum and between the upper portions of the two rows of brachioles but rising a little above their closed tips, there is a linear series of three somewhat razor-shaped plates with their broad and slightly concave backs uppermost. I have called these wing plates and have outlined the exposed surface of two rows of them in figure 1 of the text. In plate 6 at a, b, c and d, are different views of four first wing plates; b and c show outer surfaces [the proximal end of c is probably the lower end of the figure]. These plates lie nearest the anal piece and are the shortest. At e, f, g and h, are different views of four second wing plates. At i, j and k are different views of some third wing plates; k shows the impression of the tops of the covering plates which are more clearly shown at l, which is an outline drawing of the same face of the specimen. These last become longer than the second plates and usually terminate the row. In the specimen figured on plates 1, 2 and 3, the knife-bladelike points of these curve down to and touch the smallest end brachioles of the ambulacrum.

Figures b, f and j show surface ornamentation due to additions through growth. The first wing plate, b, was the first of its series formed and additions were made principally at its sides, its base, and its distal end. The original small second wing plate may still be clearly seen as the innermost V in figure f, and six additional periods of growth have left the arms for six additional V's or rounded ridges. This plate seems to have attained its full length at the end of the third of these seasons and thereafter only increased its hight and width. Figure j shows the same process of extension of the third wing plate and older specimens may have added a small fourth. Figure k seems to be a third wing plate that did not terminate the row. The hollow or grooved upper surface, shown clearly at d, was produced by an upward extension of the edges of the plates to keep just in advance of the extending tips of the brachioles. Figures c and g show a labyrinthine surface ornamentation much like that found on the proximal third of some radials. Traces of the same may be seen at b. In c the growth lines are very nearly obliterated, in g one does not detect them.

Water vascular system. Frequent reference to the respiratory system has been made during the description of some of the more prominent structures involved. There remain however some points which seem to be worthy of further notice and which are now presented. The 17th hydrospire of figure 2 extends into the coelomic cavity more than six times as far as the second; it is also more than 12 times as long as the functioning new ones. Its area presented for osmosis is therefore at least 36 times as great as that of the smaller ones. This would mean that in order to serve the function of respiration as well as the younger hydrospires, the flow of water would have to be 36 times as great. A large sheet charged with carbon dioxid and with the loss of nearly all its dissolved oxygen would be valueless to the organism, yet the continued growth of these old hydrospires would emphatically indicate increase of function.

That there was an increase of function is also shown by the deposit of exceedingly fine sand or clay colored by limonite which we find to be greatest along the inner edges of the largest hydrospires and which is represented by cross hatching in figure 2. This deposit seems to have been swept in just before death and after the falling of the theca to the sea floor.

The flow of water was down the brachioles into the brachiolar chambers, which also show the presence of the same yellow deposit on their walls, and from here to a small extent through the openings to the food grooves and so on through the enteric cavities; but to a very much greater extent (and freed of its food content) through the pores opening into the hydrospires and out at the base of the deltoid. I have before referred to the evidence of greater functional activity at the middle of the base of the deltoids, and the upper row of interbrachials may also be associated with this function. In fact the appearance of this upper row is remarkably suggestive of gradual increase in number at their ends. Whether the hydrospires pass under this row or not is as yet unknown.

The comparatively slight difference between the older and the newer brachioles and the very probable great difference of water flow in the corresponding hydrospires are suggestive of openings connecting each brachiolar chamber with the others of the same row (of which we have already had evidence) and of a marked flow of water through them toward the peristome but remaining outside of the probable covering plates of that area. This arrangement would secure the required greater flow for

the older hydrospires and the marked widening of the ambulacrum toward the same area in this species (and in Asteroblastus and related forms) is to me indicative not alone of the required slight increase of size of the food groove but also of the increase of the functions of respiration and reproduction.

At certain points in grinding down the section shown in figure 2 there was visible a small rather square figure outlined by carbon particles and lying directly under the inner ends of the adambulacrals. This suggests a radial water canal which may have been connected with the hydrospires through side branches. If this additional structure existed the similarity between this ambulacrum and that of an asteroid would be extraordinary, the hydrospires being comparable to ampullae and the lining of the brachiolar cavities to podia.

Anal piece. The wing plates radiate from a high central star-shaped plate apparently formed from five consolidated orals or from five upper or orad portions of the deltoids as shown in figures of Asteroblastus where the food grooves are made to pass over the outer edges of a starlike central portion which resembles in a very remarkable manner the central piece of Blastoidocrinus. In the latter species however the food grooves lie on a horizon but little above the bases of the brachioles or at a depth below this apical piece equal to the sum of the extreme depth of a wing plate and the hight of the massive covering plates. A reference to plate 2 will show how far down this must be. The apical piece stands in the same relation to the covering plates of the peristome as the wing plates do to the covering pieces of the food groove. There is plenty of room under this piece for a series of covering plates as in Nucleocrinus but with the anus thrust through them and by a bend above them opening laterally at a surface flush with the grooved side of the plate and just back of the peculiar brachiole of the anal interradius. Thus the apical piece might better be considered as formed of fused anals than of fused orals. We may note that it is possible that the anus had no external opening. If echinodermal respiration may be in part effected by water entering the alimentary canal by either mouth or anus (as in the " respiratory trees " of holothurians, the " accessory intestine " of echinoids and the " ventral sac " of crinoids) we may possibly have here a somewhat similar condition of things in which there is a flow from the rectum over the covering plates of the peristome and swept away through the older and larger hydrospires.

A series of sections or the gradual grinding down of the oral portion of the specimen figured in plates 1, 2 and 3 would no doubt throw much light on this subject but it seems better to await the finding of other fragments rather than to further mutilate so perfect and unique a specimen.

Views of these fused anal plates may be seen in plate 7. Figures a to o represent the under surfaces of a series arranged according to probable age, an ontogenic series. The piece is at first rather thin, its vertical axis less than half of its horizontal and showing no sign whatever of a central perforation. The piece at a is tilted a little to show its thinness. Figures b, c, d, e and g show the beginnings of an indentation which becomes very marked as the piece increases in age. The more mature pieces l and o show also other indentations. The piece has grown principally by additions to its under surface and to a less extent to its edges. The deeper indentation is rather suggestive of a bend of the rectum, the anal interradius being perhaps the lower in the figure. The interradial indentations in figure o may be the impressions of plates covering the peristome. Figures p, g and x are of upper surfaces showing the grooving caused by increased upward growth due to more extended additions to the plate edges as in the wing plates. Figure g is the anal piece of a regularly four rayed or tetramerous specimens while figure x is of a specimen having its anal piece of six fused plates and possessing a small sixth ray. The vertical axis of these pieces is increased in some specimens to nearly three times their horizontal diameters.

Stem. Billings described the stem as " round with an alimentary canal so small that often the detached joints seem to have no central perforation . . . the flat faces of the separate joints exhibit strong radiating striae." The diameter of the stem of the specimen shown in plate 1 is 3 mm while the joints themselves have a thickness of about 1.4 mm as may be seen in plate 3, upper figure. The last joint left on the stem fragment of this specimen seems to be split across in a direction nearly parallel with the plate face and while it shows a central perforation about .3 mm across, or one tenth of that of the stem diameter, it does not show the strong radiating lines mentioned by Billings. Associated with the fragments of this species, however, are stem joints and roots shown in plate 7, figures r to w, which do show these lines. These stem joints are not abundant here and this would indicate a short stem. I have found no evidence as yet that the stem pene-

trated the theca to the depth figured by Billings and so deep a penetration in his specimen may have been the result of partial crushing or deformation due to pressure.

Taxonomic position. Before attempting to discuss the position of this curious species with its approximately 50,000 plates and ossicles it may be well to point out that the close to 90 plates of its aboral surface do not necessarily point to a generalized type of low rank.

A period of stress developed the many centers of stereom formation and the numerous and irregular plates of a form like Eocystis, but protection in this direction once secured in its adjustment to its environment, there could occur the passive loss, through the mechanism of inheritance, of a plate or so at a time and the others would simply extend their surfaces a little more to keep up a compact exterior. New crossings would tend to replace loss, but a Mendelian factor has entered that tends to simplicity and though loss be slow it is nevertheless sure until it begins to interfere with some other function. Thus the few thecal plates of a Cryptocrinus are indicative of a higher genetic position. A period of stress for some other function would require response or extinction and again lead to proliferation of parts as in stem or brachiole development. The law briefly expressed is that the quiet of an unexacting environment for any part leads to numerical or other simplicity of that part, and that the stress of an exacting environment, on still plastic parts, leads to gain in numerical or other complexity of that part.

Our form seems to have been living in a period of stress in relation to respiration and reproduction. We therefore find five points of what we may call primary meristem, developing adambulacrals, covering plates, wing plates, brachioles, plates lining brachiolar chambers, and hydrospires; and exciting the neighboring deltoids and bibrachials to constantly add to their area. This increase of area to the strong bibrachials would tend to lift the oral surface away from the interbrachials. These interbrachials are away from the points of activity and any extra activity on their part might lead to serious interference with the larger water exits of the deltoids. Release of pressure would render the water outflow the easier and in the membranous margins of the extending ends of the hydrospires new centers of stereom formation would naturally arise and fill in a series of plates representative of the external stereom thickening of the hydrospire folds of Codaster. The result would be a partial fourth circlet of supplementary plates, either homologous in part with the stereom formation of the inner surface of the

deltoid [as in fig. 3] or from new centers of stereom formation and therefore homologous with no plates whatever. It is very highly probable that these plates of the fourth circlet are associated with respiration and that there is a regular increase in their number, newer plates being formed at both ends of the row until as many as 20 were formed in each interradius. The remaining plates of the aboral surface and the five single interambulacrals of the oral surface are really indicative of a rather highly specialized type.

The anal piece, the wing plates, and the brachioles of our genus might perhaps cover an oral surface much like that presented by Asteroblastus and its large number of thecal plates and very remarkable apical piece are suggestive of relationship. Our genus however possesses no diplopores and the remarkable differentiation of the plates of the aboral surface and the unique system of hydrospires clearly separate it from the Protoblastoidea of Bather (1899). The resemblance of the central plates of the oral surface of one to those of the other, seems to be but another example of homoplasy.

While the deltoids of Codaster offer some remarkable resemblances to the genus under discussion, we may note that our form still has more than " the normal definite number of plates "; the hydrospires do not cross over to the radials; the radials not only are not notched but they are not even in contact with either deltoids or ambulacra, being separated from both by the peculiar large and long bibrachial. The structure of the ambulacrum with its adambulacrals spanning the space between the deltoids, the absence of a lancet plate, and its peculiar wing plates and anal piece offer characters more than sufficient to separate the form from the Eublastoidea [Bather, 1899].

The structure of the ambulacrum on the other hand would at once suggest a position with the Edrioasteroidea as would also the torsion of the oral over the aboral areas of some 7 to 10 degrees toward the right, but the presence of brachioles, not to mention other differences of structure, would exclude it from that group.

The form seems also to suggest several rather remarkable crinoid affinities. Here we have the marked basal invagination of many forms, the strongly crinoid radials, the group of interbrachials, and at least the suggestion of brachials in the pairs of plates assuming that position. These characters all exist on a differentiated aboral surface and the structure rather closely resembles the crinoid cup. The oral surface is just as extraordinary. Here we have the crinoid tegmen with its five deltoids as in Carabocrinus, its introduced anal

plates, and its food grooves with their covering pieces leading to the mouth.

We must not make too much of the absence of true brachials. The primary meristem in our species has already formed just such a linear series of single plates (the wing plates) on the upper surface of a ray. Does this radial series of single large plates give an excuse for the announcement of a new class of Echinoderms separate from all others? We may imagine our primary meristem to start a new wing plate and then push up between it and the last formed. This would give an outer brachial to a now ascending uniserial arm. It would also require but a slight modification of the structures formed by this meristem to produce an ascending biserial arm with its fringe of pinnules. The ascending arms would at once retire the tegmenal brachioles from service and the modification or loss of these and adjacent structures would follow. In my description of Carabocrinus geometricus,[1] I suggested that the tegmen had plates bordering the lateral sides of the deltoids and thus underlying the food grooves. Figure 2, plate 1, of that report would suggest such a condition but the figure does not do justice to the specimen. The notches for the bases of the deltoids are more regular than in the figure and the angles at the corners should have their outer sides running parallel with the lines taken by the missing food grooves. These bordering plates might be homologous with the adambulacrals of Blastoidocrinus.

The affinities of this genus seem to associate it most clearly with the Blastids but under neither grade as defined by Bather. I propose a new order for this genus under the name of Parablastoidea and with the following characters.

PARABLASTOIDEA

Blastoidea with the theca more or less clearly separable into an oral and aboral surface. The aboral consists of three or more circlets of plates. Basals (unknown); five radials, in contact all around; five pairs of plates over the radials and supporting the distal ends of the ambulacra (bibrachials of Blastoidocrinus), and between them and completing the third circlet a group of smaller plates (interbrachials of Blastoidocrinus) arranged in one or more transverse rows. The oral surface possesses normally five ambulacra without a lancet plate but with adambulacrals meeting under the food grooves, with covering plates and with numerous

[1]N. Y. State Pal. An. Rep't. 1903. p. 282.

brachioles. Respiration by means of hydrospires crossing one or more interambulacral plates, the water flow passing down the brachioles into a series of brachiolar cavities from which the hydrospires are reached through pores passing between the adambulacrals.

Pachyocrinus crassibasalis Bill.

Can. Org. Rem. Decade IV. p. 22, pl. 1, fig. 3 a-b

The wing plates of Blastoidocrinus and its closely terminal anus remind one strongly of some species of Eucalyptocrinidae and the resemblance is no doubt due to homoplasy. As we have in the Chazy limestone a form of crinoid which may also have possessed
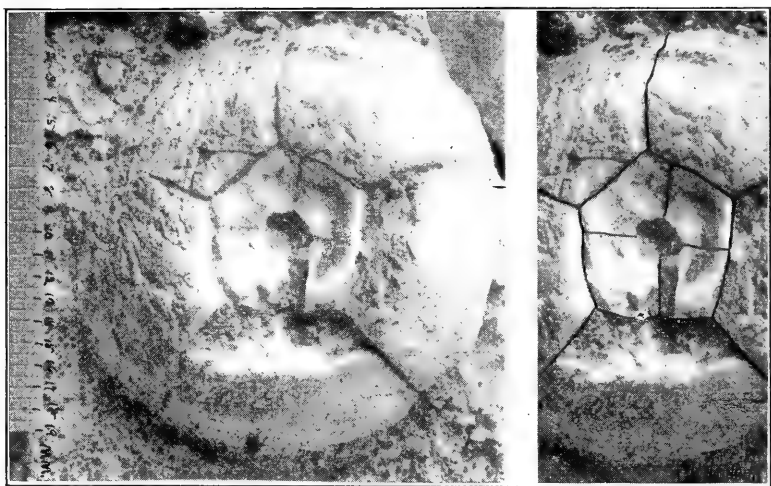
Fig. 4 To the left, a reproduction of an untouched photograph of P a c h y o c r i n u s c r a s s i b a s a l i s. To the right, a portion of same with the sutures lined with ink. It will be seen that the specimen has but four basals. The five heavy radials still have their upper edges buried in the matrix.

similar plates and as Mr Billings immediately followed his description of Blastoidocrinus with this still more difficult puzzle it may not be out of place for me to here again call attention to this neglected species.

From the accompanying cut [fig. 4] it will be seen that this form has four basals, not five as Billings describes and figures it. Figure 4 is reduced from a photographic enlargement of the type specimen, the portion of the figure to the left is untouched, at the right is a part of a print from the same negative with the sutures darkened with ink. Billings says of the heavy plates that they "may be either subradials or first radials," which in our modern terminology

would read "either basals or radials." They are undoubtedly radials and c r a s s i b a s a l i s is rather a misnomer. The specimen should have been named c r a s s i r a d i a l i s and it seems to belong to the Eucalyptocrinidae. It would, I believe, be possible to uncover the edges of these radials and thus determine the number and something of the character of the third circlet of plates. I am deeply indebted to Dr J. F. Whiteaves for the loan of this specimen and I have figured it here in the hope that some one may lift it out of the list of indeterminable names. The genus and species are both good and the form must be reckoned with in the future study of these interesting primitive groups.

<div align="center">

DEOCRINUS gen. nov.

δέω, to bind; κρίνον, a lily

Genotype R h o d o c r i n u s a s p e r a t u s Bill.

</div>

Calyx globose, with a rather narrow and shallow basal concavity, involving the small interbrachials and about one third, or less, of each basal. Primibrachs two, *second* secundibrachs are unsymmetrical, secundaxils each giving off a large pinnule with very deep ambulacral grooves, which is incorporated with the cup and the first ossicle of which meets its opposite neighbor over the topmost interbrachial in each interradius: the *first, third* and *fifth* secundibrachs are nonpinnule bearing; all subsequent brachials bear pinnules and the first two of these have also become a part of the cup or meet to form a weblike extension of the bases of the arms.

Arms, so far as shown, but two to each ray, the brachials uniserial at least up to II Br$_9$, beyond that unknown; one or two intersecundibrachs are present in each radius. Tegmen composed of some hundreds of small rounded pebblelike plates extending out over the ambulacral grooves of the lower pinnules and the base of each arm. Anus nearly central and having a tube whose stout lower plates are arranged with their long axis radially disposed. Anal interradius differing but little from the others.

Remarks. "Archaeocrinus has a more elongate calyx . . . has no anal tube, and never supplementary pieces "[1] in the interradii such as we find in the genotype of Deocrinus. There is also an absence of the median ridge over the brachials in this genotype and the upper interbrachials do not " connect imperceptibly with the plates of the disc "[2] but the plates of the tegmen are separated

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[1] Wachsmuth & Springer. The Crinoidea Camerata of North America, p. 250.
[2] *Ibid.*

from the interbrachials by the meeting of the first pinnules of each arm with those of its neighbors.

The last character also separates the genus from Diabolocrinus and in addition the tegmen is not composed of " rather large plates " but of numerous very small ones.

The incrusted and imperfect condition of this unique genotype which for nearly 50 years has remained the only specimen of the Rhodocrinidae found in the Chazy fauna has caused it to be rather neglected and as yet a good plate, a fairly full description, or a cup analysis of it has not been published. The two additional species of this family published in the report of the State Paleontologist for 1903 and the three new species which follow seem to demand a more complete description of this interesting first species of Billings and I therefore offer the following:

Deocrinus asperatus Billings (sp.)

Rhodocrinus asperatus Billings. 1859

Plate 8, figures a and b; cup analysis figure 5 of text

Diameter of calyx across zone of primaxils 12.5 mm, narrowing above to 11 mm at level of tegmen; lower half of cup a hemisphere; diameter of basal concavity 4 mm.

Infrabasals with their inner ends bent upward at right angles forming a tubular chamber appearing to be a continuation of a large circular stem lumen 1.5 mm in diameter; the outer horizontal shoulders of these plates bear the impression of the proximal stem joint 2.5 mm in diameter [fig. 5]. Each plate bears a faint raised central, radial ridge representing a suture of the proximal ring and on either side of this there are eight or nine short cuneiform elevations making a well marked outer circlet, within which is a second circlet of fainter radial lines.

The basals may be divided into three transverse portions: first, a rather smooth concave inner third, forming the outer portion of the basal concavity, bent at an angle of about 90 degrees with the middle portion of the plate and bearing only very faint and short radial lines, the boundary marked by a strong raised ridge, these ridges making a well marked basal pentagon with the rounded angles on the plates; second, a rather smooth outer fourth, bent inward at an angle of about 45 degrees and forming a concave margin to the plate ornamented only with numerous extremely fine, raised, irregular ridges usually running toward the interradial plates; the boundary of this portion marked by a well defined raised ridge concave toward the base of the plate; in other Rhodo-

crinidae this ridge usually is continued as an unbroken line along the margins of the radials and brachials up to II Br$_1$, but in this species is broken once or twice on the basal, is lost at the sutures, and appears along the other plates only as a series of rough, elongated tubercles; third, the middle portion of the plate shows a few
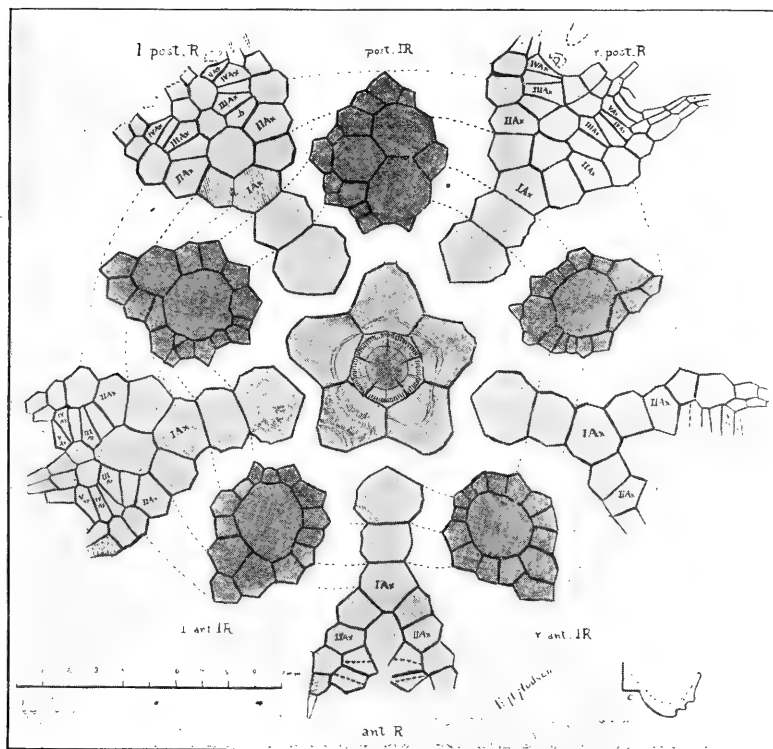
Fig. 5 Analysis of D e o c r i n u s a s p e r a t u s. The basal and interradial elements are shaded. Between the interradial sutures of the infrabasals the raised casts of the sutures of the proximal stem joint have been faintly indicated. In the lower right-hand corner is an outline of a vertical section through a basal and an infrabasal. The shoulder of the latter which bears the impression of the proximal ring of the stem is shown at C.

prominent raised tubercles on either side which indicate ridges which are also represented on the radials by similar tubercles.

The radials present about the same area as the basals. The first brachial is smaller and bears also a median row of tubercles. The primaxil is still smaller. The first secundibrachs and the inter-secundibrachs are nearly the size of the primaxil, the arm plates become abruptly smaller at II Br$_3$, the first plate of the first pinnules is nearly as large as II Br$_2$ and is in contact with the three next following brachials.

In all but the anal interradius there is a single large plate completely surrounded and separated from all other plates by from 13 to 14 " supplementary " plates in contact with it. The two upper plates of this circlet are usually the larger and are capped by an additional plate over which meet the first plates of two opposing pinnules. In each right and left posterolateral interradius additional supplementaries increase the total number of plates to 18, the post. IR has two large plates neither of which is completely surrounded by supplementary plates next the r. post. R.

The third plate of each first pinnule sends inward two thin sheetlike extensions, one each side of the very narrow ambulacral groove, that are five or six times as long as the width of the face of the plate and reach more than halfway in toward the center of the tegmen; the plates above this send in shorter extensions and the fifth plate reaches the edge of the tegmen. The second plates of the second pinnules (the first inner pair of each radius) have similar sheetlike extensions; the upper edges of the contiguous sheets of these pinnules are covered with a single row of rather large tegmenal plates.

The tegmen appears to have been supported by a radial series of struts formed in this manner and preventing an inward closing of the bases of the arms; the tegmen would thus be rigid, not flexible, and would be nearly flat, the arms closing over it.

On a level with the upper edge of the first plates of the third pinnules and midway between them and the top of the second plates of the second pinnules there is a rectangular opening into the calyx (10 in all) and a little distance above this is another and larger channel, the food groove, directly roofed over by the small plates of the tegmen, and the ambulacral grooves of the third joint of the second pinnule lead into this opening. The ring of larger plates around the anus is not complete but open toward the center of L. post. R.

Remarks. I am again indebted to Dr J. F. Whiteaves for his courtesy in allowing me to give some time to the study of this specimen. I wish also to express my obligation to Mr Walter Billings who sent me a cup analysis he had made of the same, showing about 140 plates.

By removing incrustation from the cup, I have been enabled to represent some 90 additional plates but otherwise my analysis does not differ from that of Mr Billings save in the lost calyx plates of L. post. R. (shaded) where I find indications of but two missing plates where Mr Billings gives three.

HERCOCRINUS gen. nov.

ἔρκος, a snare; κρίνον, a lily

Genotype H e r c o c r i n u s   e l e g a n s

· Calyx more or less flattened at the base with a basal narrow concavity involving less than half of each basal; infrabasals very small and completely covered by the column.   Radials nearly equal in size to exposed portion of basals.   Primibrachs two, first secundibrachs are unsymmetrical secundaxils each giving off a large pinnule which is incorporated with the cup and the first joint of which meets its neighbor over the topmost interbrachial; all subsequent brachials also bear pinnules and the first two of these are also incorporated with the cup or meet to form a weblike extension of the bases of the arms.   Arms two to each ray, the brachials of each zigzag up to at least the tenth, beyond that unknown; intersecundibrachs absent.   Tegmen of very numerous small plates forming a basin whose margins extend upward on the arm bases and whose center is more or less elevated in a nearly central mound containing the anus.   Interradii often differing from each other in the arrangement of their plates, the radials usually separated from each other by two interradials.   One or more larger central or eccentric plates more or less surrounded by other interbrachials. Supplementary plates present but not so numerous or so regularly arranged as in Deocrinus.   Anal interradius not to be clearly distinguished from the others.   Stem circular, lumen about one sixth the stem diameter, pentagonal, the angles at the stem joints and therefore radial in position.

Remarks.   Hercocrinus may be distinguished from Diabolocrinus by its narrow basal concavity; its completely covered infrabasals; its interradial spaces do not "connect with the disc plates, or, properly speaking, pass into the disc" [W & S]; the anal interradius is not wider than the others, the ventral disc is composed of very small, not "rather large plates" and the column does not possess a pentalobate canal.   The tegmen is more like that of Archaeocrinus but the calyx is not elongate, the arms do not branch and supplementary plates are numerous.

Hercocrinus elegans sp. nov.

Plate 9; cup analysis figure 6 of text

Description of type.   Cup 12 mm wide, 7 mm high, base flattened, rather pentangular.

Infrabasals completely concealed by proximal stem joints, basal pit or depression 4 mm in diameter or but little more than the diameter of the stem joints which measure 3.5 mm.

Basals with smooth transverse elevated ridge, angled on the plate, making a pentagonal boundary to the basal concavity. There is a transverse raised ridge near the outer edge of the plate, and between this and the first there are three finer ridges the innermost of which meets the angle of the first mentioned ridge. Between this last finer ridge and the heavy transverse one the plate is depressed, the inner angle of the radial is also depressed and thus two basals and a radial unite to form a well marked depressed
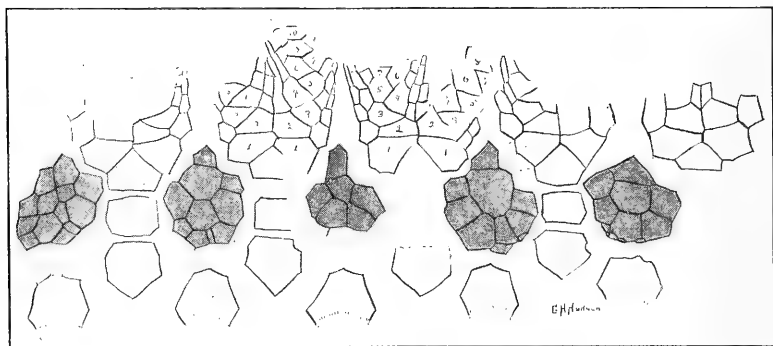
Fig. 6 Analysis of H e r c o c r i n u s e l e g a n s. The interradial areas are shaded. The one at the extreme left is likely to have some fractures represented as sutures. This side of the theca was crushed in. The fourth interradial area from the left is the one to the front in the upper figure of plate 9. The same interradial area is also the upper of the two interradial areas in part shown in the right-hand portion of the lower figure. The rounded, gemlike surfaces of the plates of these areas and the tendency to form small supplementary pieces is well shown.

triangular pit; one basal is marked by two short lines within this pit, in the others it is smooth. The outermost of these plate ridges crosses the suture and continues over the sides of the radials which are slightly smaller than the exposed surface of the basals. This marginal ridge is about .6 mm from the edge of the plate and marks off an outer depressed, smooth and concave surface (the outermost edge of the radials being again slightly raised where they meet the interradials). Some of the finer lines of the basals after passing over the radials are continued up the brachials in an irregular manner as a fine central line, with here and there others, on a strongly convex medial space which otherwise would be remarkably smooth. The brachials are also edged with a very smooth concave border like that on the edge of the radials.

Interradials and interbrachials with highly convex somewhat polished surfaces resembling a setting of precious stones. The cup analysis, figure 6, shows best the relation of these but in the crushed interradial areas a few of the lines may be due to fractures instead of sutures. Plate 9 will show clearly the appearance of some of these interradial " jeweled " areas.

Tegmen of some hundreds of very small plates running out to and a little over the bases of the arms and merging into well defined rows of covering plates. The tegmen with this extended covering of the arms and pinnules forms a wide and rather smooth basin save for the pointed elevations of the tegmen plates. The tegmen has been crushed in on one side and the structure of the anus is not clearly manifest.

Remarks. This species is closely allied to L y r i o c r i n u s ? b e e c h e r i Hudson[1] and the latter belongs to the present genus and should be known as H e r c o c r i n u s b e e c h e r i. H. b e e c h e r i lacks the larger more flattened and pentangular base, the five prominent triangular indentations of which the lower angle of each radial forms a part, and the more numerous convex polished interradials of H. e l e g a n s.

Hercocrinus ornatus sp. nov.

Plate 10; cup analysis figure 7 of text

Description of type. Cup nearly globular, greatest width 13.5 mm, at base of primaxils; narrowing above to 11.5 at II Br$_2$. Immediately above this plate the arm starts outward at an angle of about 45 degrees. From the bases of the primaxils the cup curves regularly downward to a width of 5 mm at the edge of the basal concavity. Vertical hight from base to tegmen 11 mm.

Infrabasals small, completely hidden by the proximal portion of the column. Basals with a rough raised transverse ridge which forms a raised circular border to the rather narrow basal convexity. From this ridge the face of the plates is directed outward at an angle of the cup. In addition to this ridge there is another rough and prominent one parallel with it but near the outer margin of the basals. These plates possess a few shorter ridges and numerous pitted depressions, giving them a rather rough and reticulated aspect.

The radials are but little larger than the exposed surface of the basals, they are also similarly roughened by fine reticulated ridges

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[1]N. Y. State Pal. An. Rep't. 1903. pl. 3, p. 277.

with numerous small shallow pits scattered between. Each supports at its apex two very nearly equal interradial plates with usually a vertical suture between them.

First brachials about 2.5 mm wide and nearly square. The outer
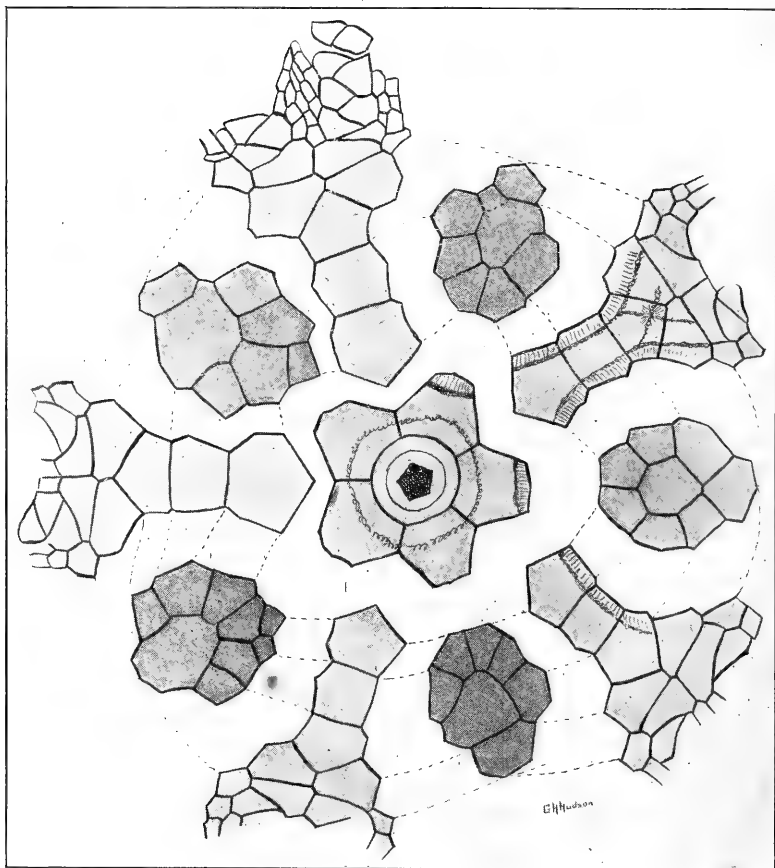
Fig. 7   Analysis of H e r c o c r i n u s   o r n a t u s.   Note that the radials instead of being "separated by a single distinct plate" are separated quite regularly by a pair of nearly equal interradial plates.   The depressed plate boundaries and raised ridges have been but roughly indicated.   The interradial area to the left of the upper one is the area shown in plate 10. Two depressions across the top of the central plate of this area are strongly indicative of sutures and one of these is represented in part by a dotted line.   The photograph made the depressions appear as sutures and they were so drawn for plate 10.   The angles of the surrounding plates in this figure would suggest that the arrangement of plate 10 is the correct one.   The fine line of the suture itself is often hard to detect.

prominent transverse ridge of the basals is continued along the edges of the radials and brachials and over the outer edge of II Br$_1$. The whole ridge forms an almost complete, raised boundary about .6 mm outside the edges of the circular or slightly oval interradial

areas. The margins of the basals, radials and brachials marked off by this ridge are depressed and concave. These ridges fork once on the radials near their upper borders and the inner branches unite to form an extremely faint medial ridge on the elevated and flattened surface of the brachials. The outer ridge forks again, rather more prominently, on the primaxils, the inner branches crossing near the upper angles of this plate and thus giving the II Br two prominent parallel ridges each.

The cup plates surrounding the tegmen are very thick and heavy and extend their lateral edges radially inward to the depth of 3 mm, a feature similar to that found in D e o c r i n u s a s p e r - a t u s . Ambulacral grooves very narrow and not showing at all on the lower plates of the first pinnules.

Bases of arms zigzag. Lower pinnules of four or five rather stout joints, each meeting its neighbor with a wide flat face forbidding an erect position of the arm bases. These bases with the arms closed would project outward above II Br_2 at an angle of about 45 degrees with the axis of the cup. For the arrangement of the interbrachials see cup analysis, figure 7.

Tegmen of numerous very small pieces extending outward over the lower pinnules and arm bases.

Anal tube short and stout, about 3.5 mm high; moundlike at its base with a width of about 5 mm; position very nearly central.

Column of nearly uniform circular rings 3.3 mm in diameter with a pentagonal lumen 1 mm in diameter; rings incised about halfway in to lumen.

<div style="text-align:center">

Genus ARCHAEOCRINUS Wachsmuth and Springer

Archaeocrinus ? delicatus sp. nov.

Figure 8

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This species is described from a fragment which is remarkably well preserved and free from incrustation both inside and out, save that some fragments of the stem and a little deposit still partly fill the basal concavity. This concavity is about 6 mm across and nearly 5 mm deep. About two thirds of the depth of this cup is due to five completely fused infrabasals leaving an inner pentagonal opening 2 mm across. All the preserved plates are remarkably thin, that is about one third of 1 mm in thickness, and all sutures are very plainly visible save alone those of this fused cup. Neither sunshine nor compound microscope shows them save

for a trace of external thickening shown on a few interradial lines and designating their position.

Basals five; a depressed distal surface about one fourth of the area of the plate bears about 16 very fine, slightly rough, uniform and parallel ridges which are set at right angles to the edge of the plate and cross over the suture and on to the interradials; from their common suture to this depressed portion there are about 24 similar lines running also at right angles to the edge of the plate and crossing over the suture and on to the radials; the proximal fourth of the plate is bent rather suddenly upward to form
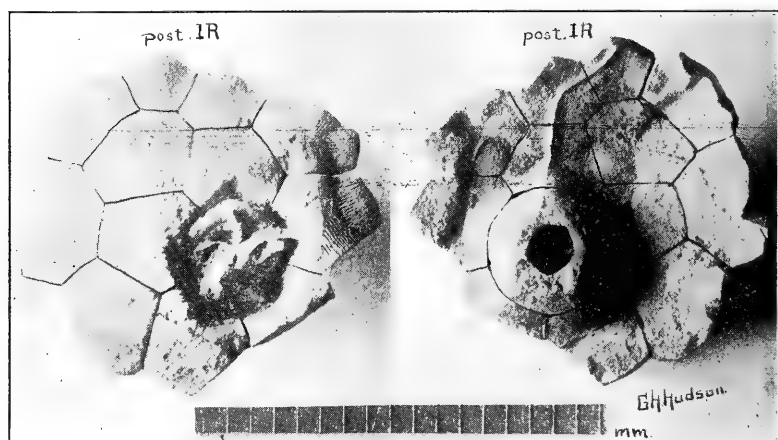
Fig. 8   At the left is a reproduction of a photograph of the exterior of a basal portion of Archaeocrinus? delicatus. The fine, parallel, ornamental lines of the plates are lost in the reduction save in part in one plate to the right where they had been strengthened a little with a fine pen. At the left is a view of the inner surface of the same specimen. Most of the sutures have been lined with ink. The infrabasals appear flat and ringlike in the figure but they really form a deep cup with angled edges and with the plates apparently grown together to form one piece.

a portion of the basal concavity, between this bend and the middle area there is a raised stronger ridge like a V with very widely open arms, the angle turned away from the basal crater and thus forming a portion of a basal pentagonal ridge.

The radials are similarly ornamented with the fine lines, from 8 to 12 to the mm, which are set at right angles to the sutures. The radials are completely separated by large interradials without any supplementary plates. The anal interradial has an extra plate and gives an additional angle to the radial of l. post. R. The cup has a rather wide and somewhat flattened base, the distance across at level of outer suture of the radials measuring about 16 mm.

One brachial shows in l. post. R, but it bears the same ornamentation. The species is easily recognized by single plates, there being no others that can be confused with it. The fused infrabasals and the absence of a median line up the brachials make the generic reference somewhat doubtful. Each radial has a somewhat raised mound just above the middle and if these are connected with lines convex toward the angles of the inner pentagon, they will outline a raised basal portion and partly outline five depressed interradial areas. The species is described here to call attention to an example of fused infrabasals in a member of the Rhodocrinidae and to the internal visceral ridge of the anal interradius. The fused condition of the infrabasals was apparently due to the extreme thinness of the plates. Homoplasy then should perhaps lead us to expect a similar condition of things in Blastoidocrinus and in other species not yet examined.

I wish in closing to thank many of my students and others who have taken an interest in this decomposed material and have given me valuable help in assorting the same, and I wish also to thank Dr John M. Clarke for the loan of literature connected with the subject and for numerous other courtesies.

PLATE 1

EXPLANATIONS OF PLATES

Blastoidocrinus carchariaedens Billings (sp.)

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The upper figure shows the oral surface with its star-shaped apical piece. The wing plates were lost from ray IV exposing several of the covering pieces. Six of these and the outer boundaries of the double row were partly outlined with ink on the original photograph. Although the figures have been reduced to less than half the diameter of the originals, additional boundaries can still be detected. The upper boundaries of the deltoids were also marked.

The lower figure shows the aboral surface of the same specimen. A few of the sutures were lined with ink on the photograph. Pencil marks used in finding the center were allowed to remain and two circles drawn from this center. On the outer of these, small portions of extended radii were marked to show the slight displacement of the rays. With the exceptions mentioned there has been no retouching of the photographs.

The original is from a yet undetermined horizon of the Chazy limestone of Valcour island, Lake Champlain, but the position is probably near the upper portion of the middle beds.

The specimen is in the possession of E. M. Hudson.
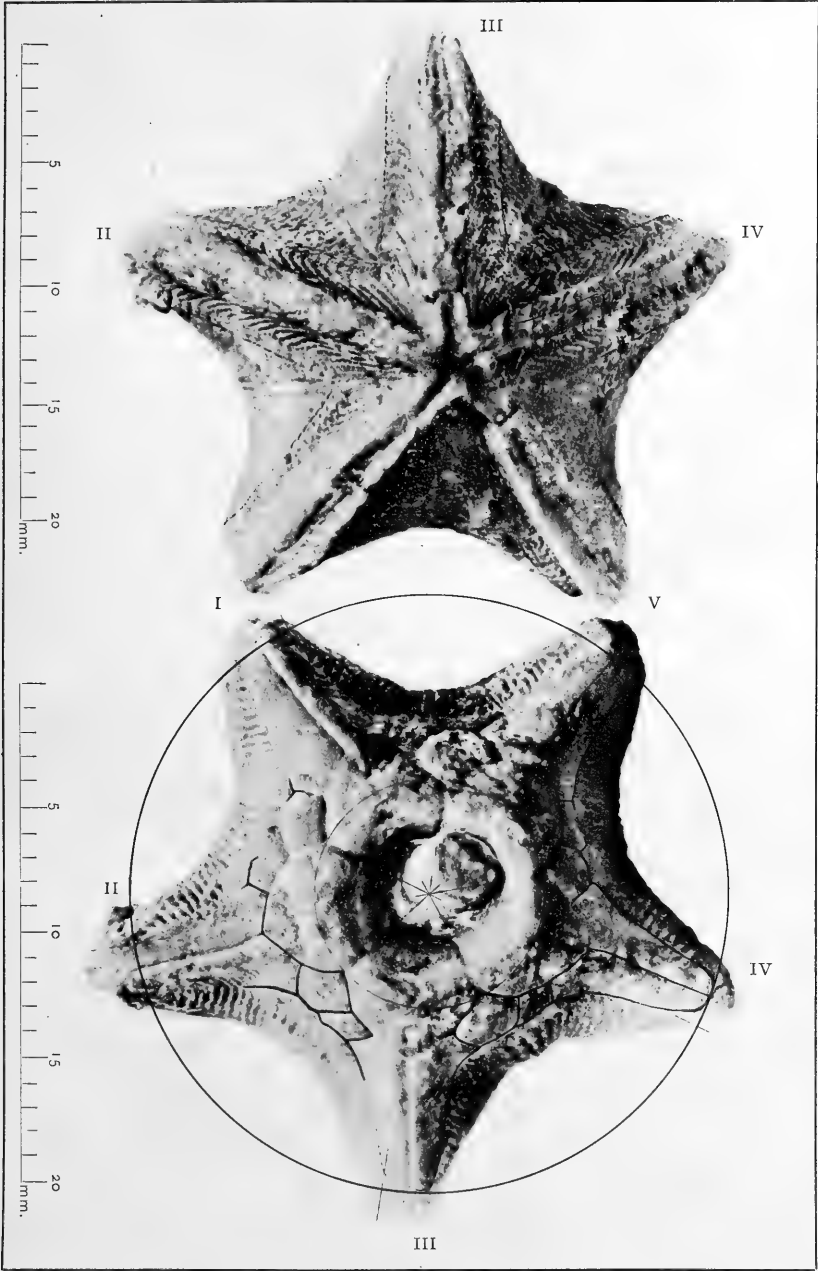
PLATE 2

Blastoidocrinus carchariaedens Billings (sp.)

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A side view of the specimen figured in plate 1. The wing plates with adhering portions of the brachioles had been broken from rays III and V. These were replaced for the photograph. A few of the sutures and a small part of the system of brachioles were marked that they might be reproduced with greater distinctness.
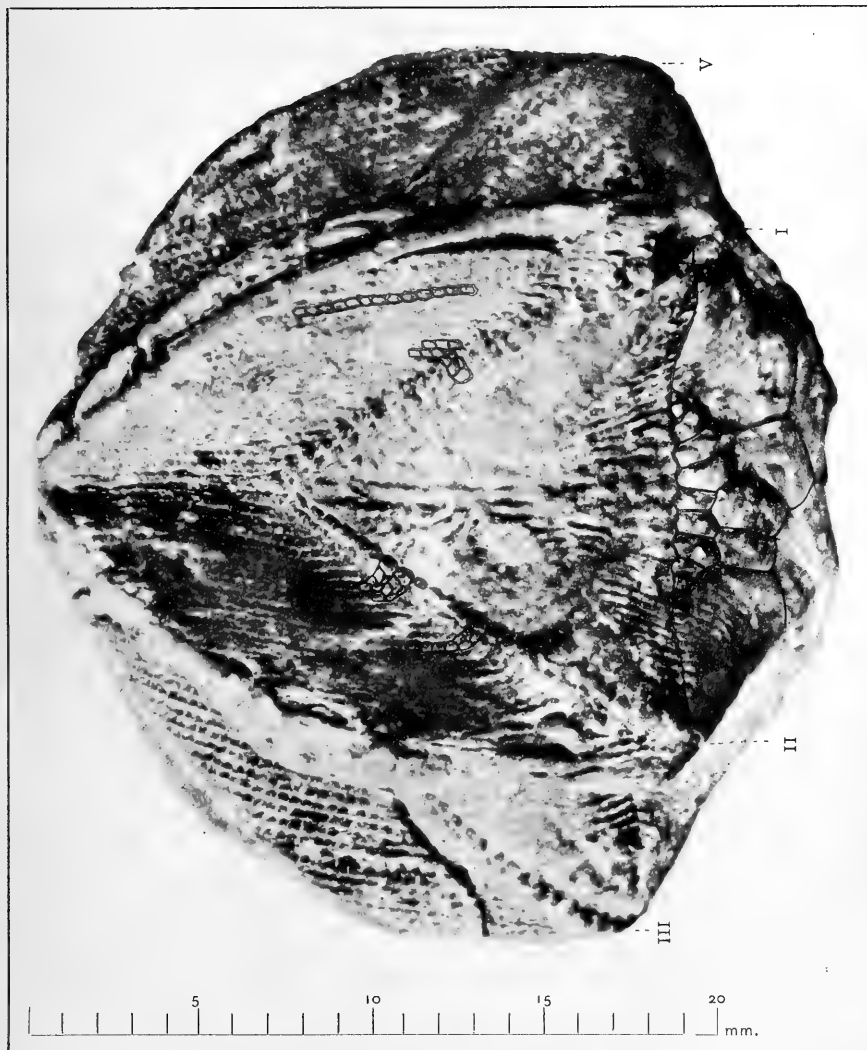
Plate 2

PLATE 3

Blastoidocrinus carchariaedens Billings (sp.)

Two views of the specimen figured in plates 1 and 2, showing different inter-radii; a few of the sutures marked with ink.

At a in the lower figure may be seen the edge of a sheet of brachioles which are bent away from the broken wing plate. In the larger photograph this edge shows traces of an inner row of side pieces. At b the deltoid is much worn, as if the plate had been rubbed against some interfering object during growth. The section of the deltoid with its hydrospires and two bounding ambulacra was made at or very close to the dotted line c
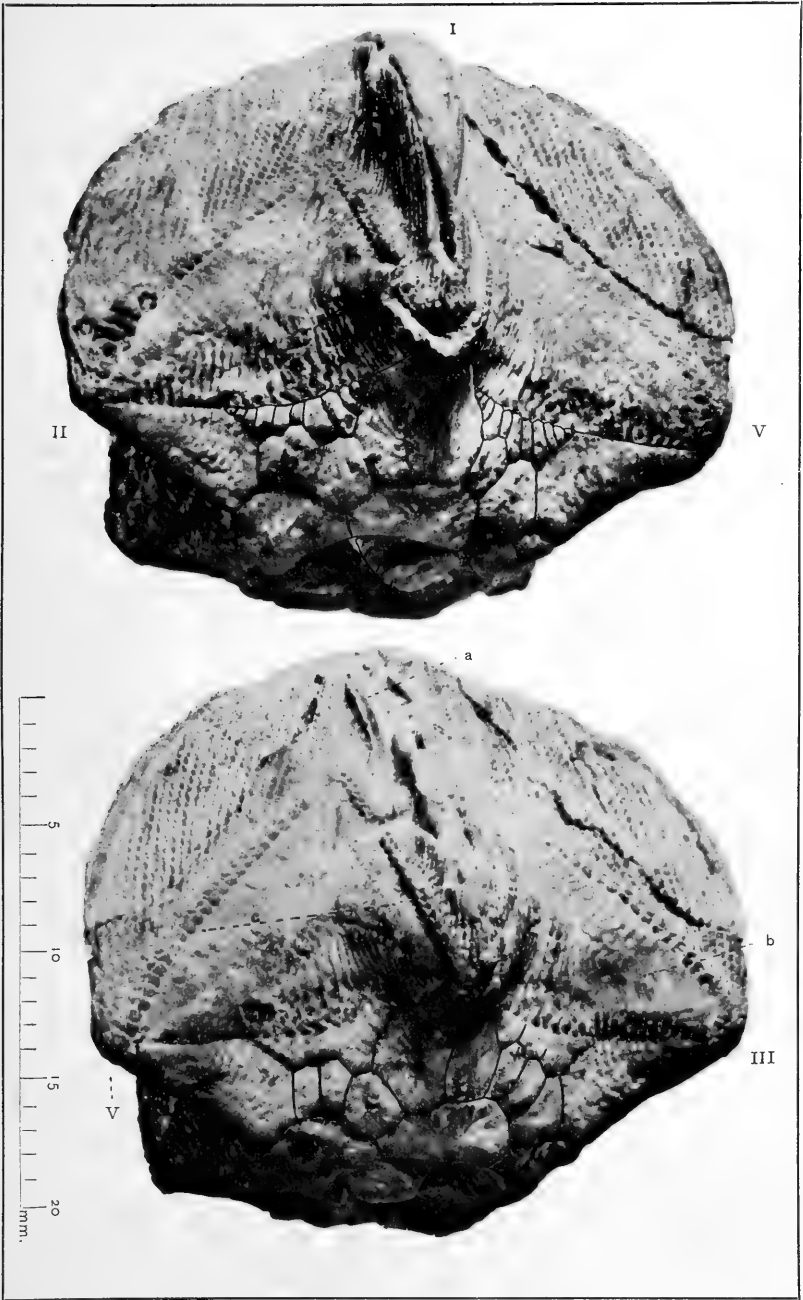
PLATE 4

Blastoidocrinus carchariaedens Billings (sp.)

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Figures a–f are of radials of different ages viewed from their bases and showing radiating grooves and marginal growth lines.

Figures g–h are of exterior surfaces of radials viewed in an inverted position. It is this surface that forms the inside of the craterlike hollow at the base.

Figure i shows the interior surface of a radial, the thick sutures where it meets the bibrachials and the larger interradials, and the narrowing at the suture to meet the smallest of the lower interradials.

Figures j–k are of radials seen from their edges; j has a vertical ridge on the interior surface for the attachment of viscera, this ridge is not present in i and k.

Figures l–n are of bibrachials; l shows two as they join each other, m shows the interior surface and the remarkable widening of the face of the suture, n shows the exterior surface, and a deltoid suture with its transverse respiratory grooves. The last plate is of a less common form, i. e. is more acute at the apex.

The plates figured show some marked variation but all are from the same locality as the more complete specimen. They are now in the New York State Museum.
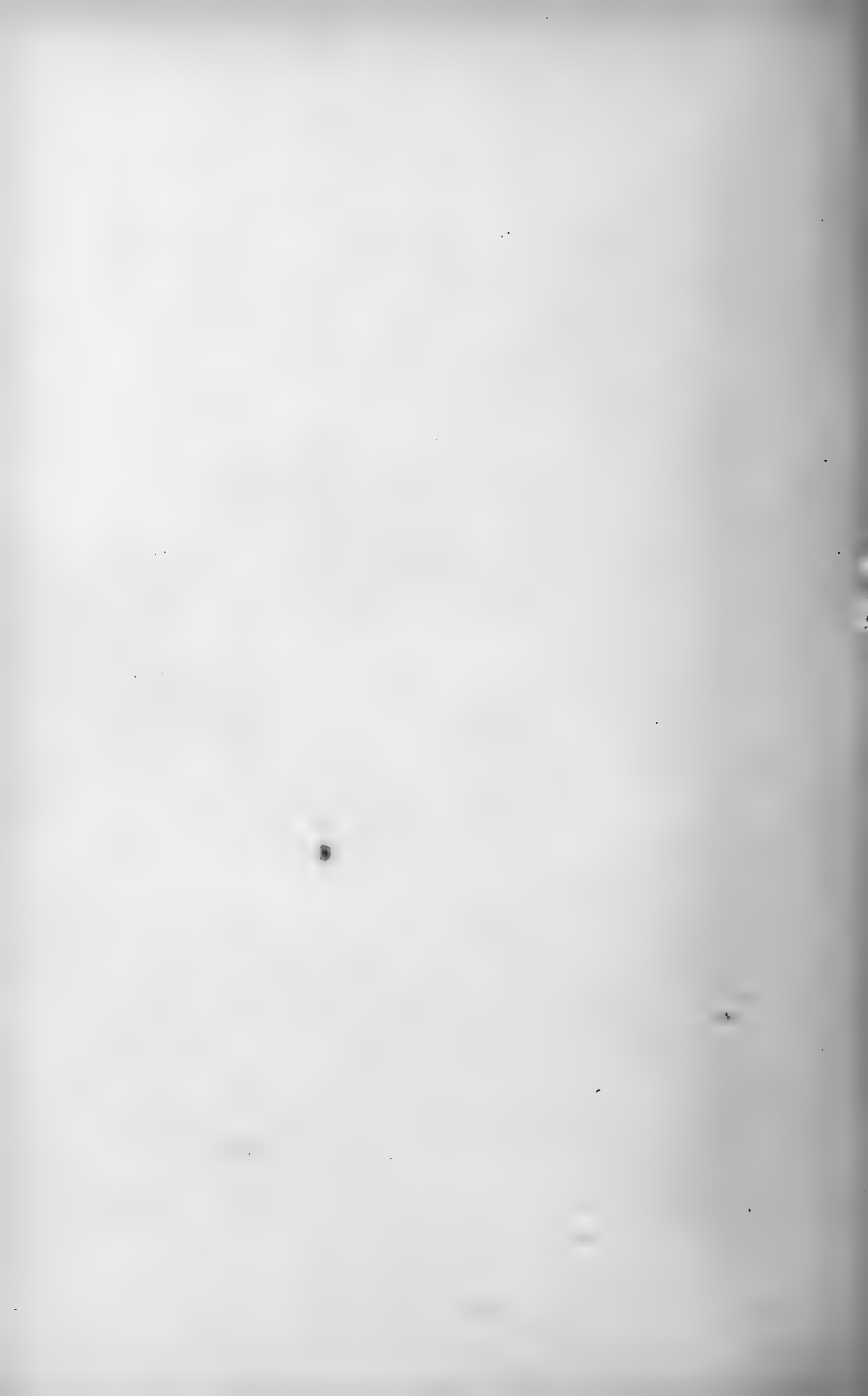
PLATE 5

Blastoidocrinus carchariaedens Billings (sp.)

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Figures a–j are views of outer surfaces of deltoids of different ages; a–d show only vertical, foldlike ridges; f–j increasing differentiation of surface markings due to additional areas added at the border; in "i" the earlier deltoid has come to lie in a margin composed of apparent folds which lie at right angles to the lateral edges of the plate; in "j" these lateral ridges are even better developed.

Figure h is unique in its surface markings and figure e in its angles.

Figure j shows clearly the incised hydrospire exits where the margin of the plate meets the displaced bibrachial. For the corresponding grooves on the bibrachial see the lower edge of figure n on plate 4.

Figures k–o show the inner surfaces of five plates of different ages. There has been no widening of the hydrospire grooves with age. Figure n shows traces of the thin sheets of the hydrospires themselves.

The specimen represented at j is the property of Mr Percy E. Raymond. The other specimens figured are now in the New York State Museum.

It may be noted that the hydrospire exits are less in number than the hydrospire folds that feed them. Two or three folds occasionally empty through one exit. There is evidence of partial or incipient anastomosis along the line of hydrospire origin.
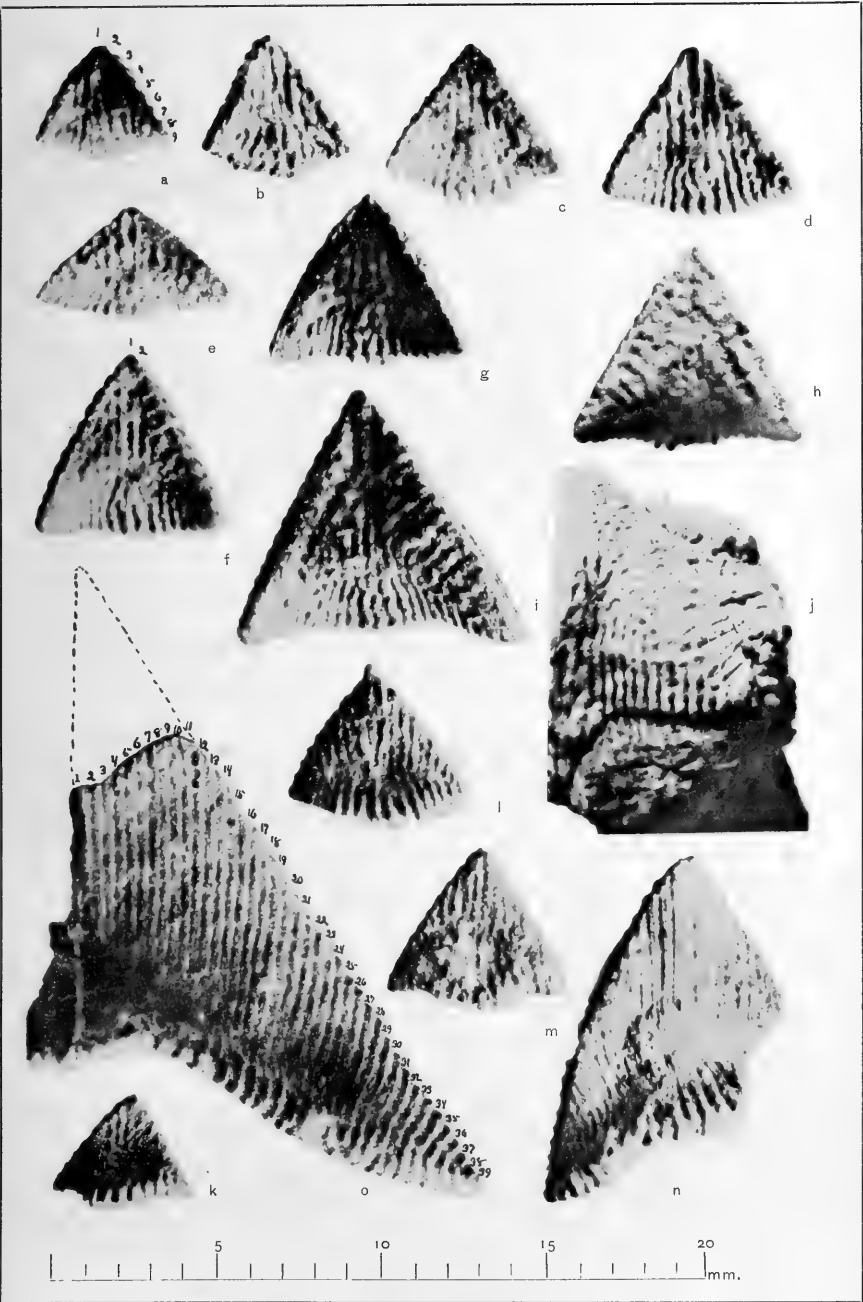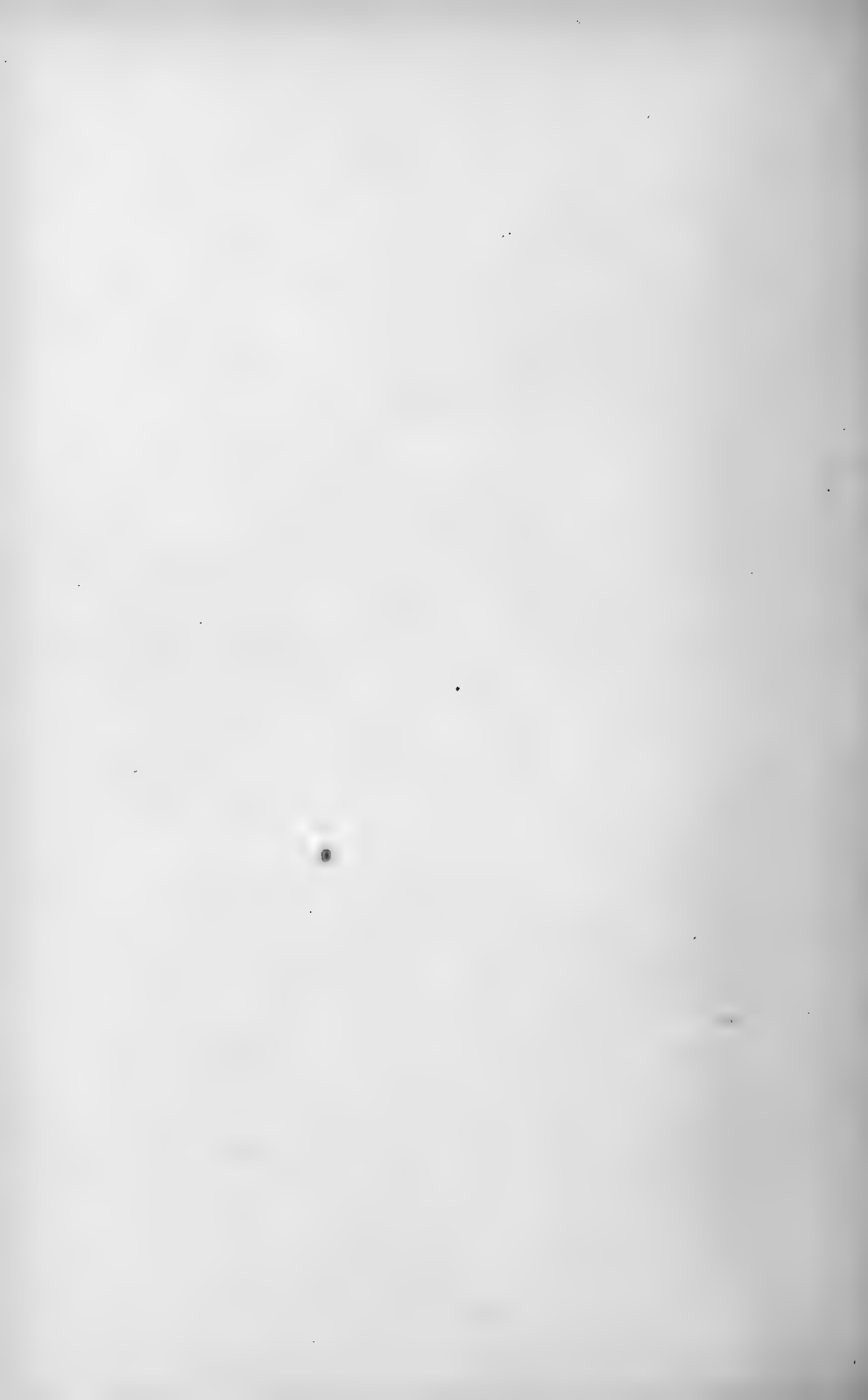
PLATE 6

Blastoidocrinus carchariaedens Billings (sp.)

Views of four different first wing plates are presented in figures a–d; of four second wing plates in figures e–h (though h may possibly represent a third wing plate); and views of three different third wing plates are given in figures l–k.

Figures a, e and i are of sides of plates, figure d shows the plate as viewed from one end, figure k from the inner edge and showing impressions of covering pieces which have been outlined in figure l, while the six remaining figures are of outer surfaces.

The ornamentation of f was produced by additions to the sides and to the lower end of the plate which were made successively after periods of rest. This marking has been more or less masked in the other plates figured. The third wing plate shown at k evidently did not terminate the line but must have been followed by a fourth.

These plates are now in the New York State Museum.
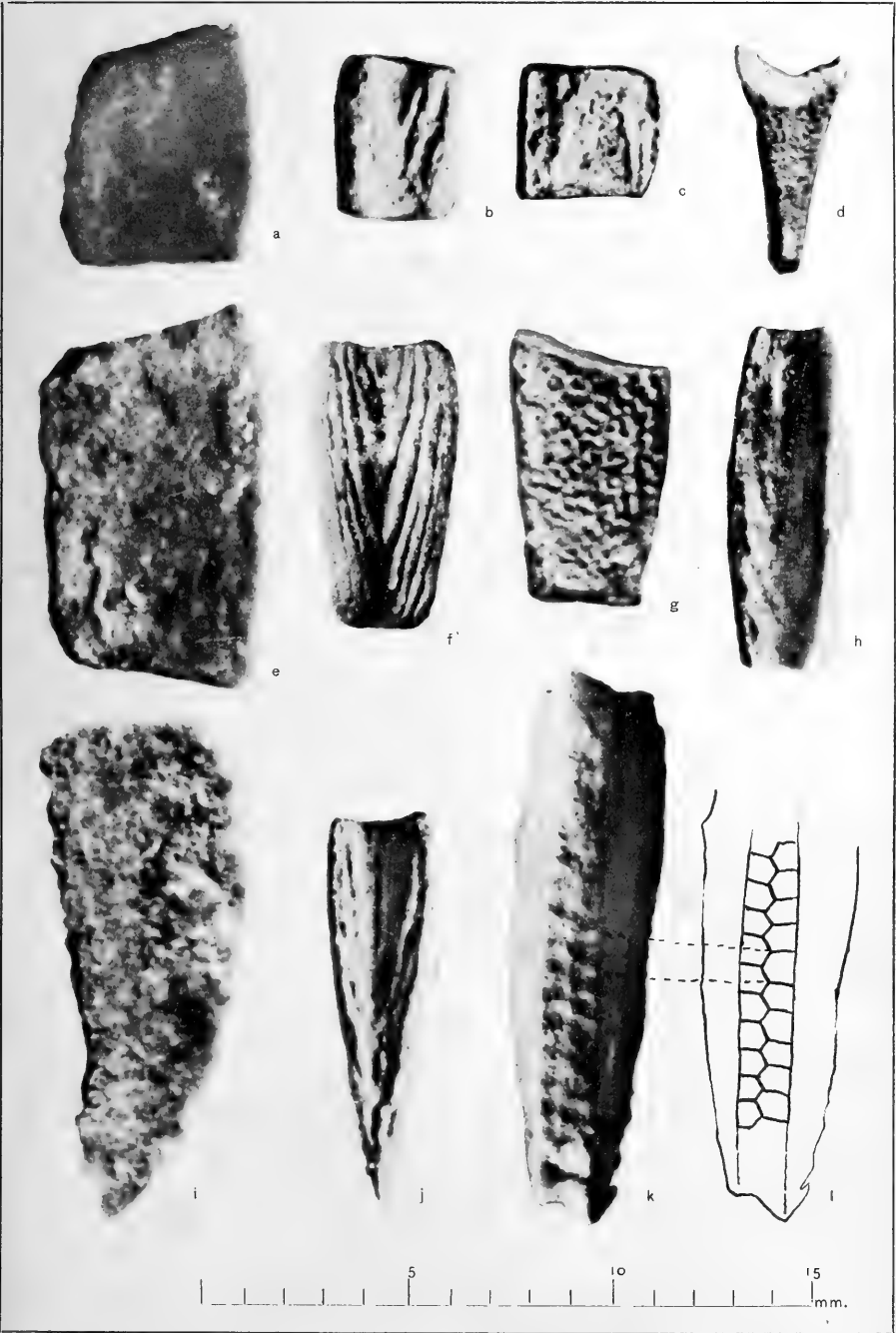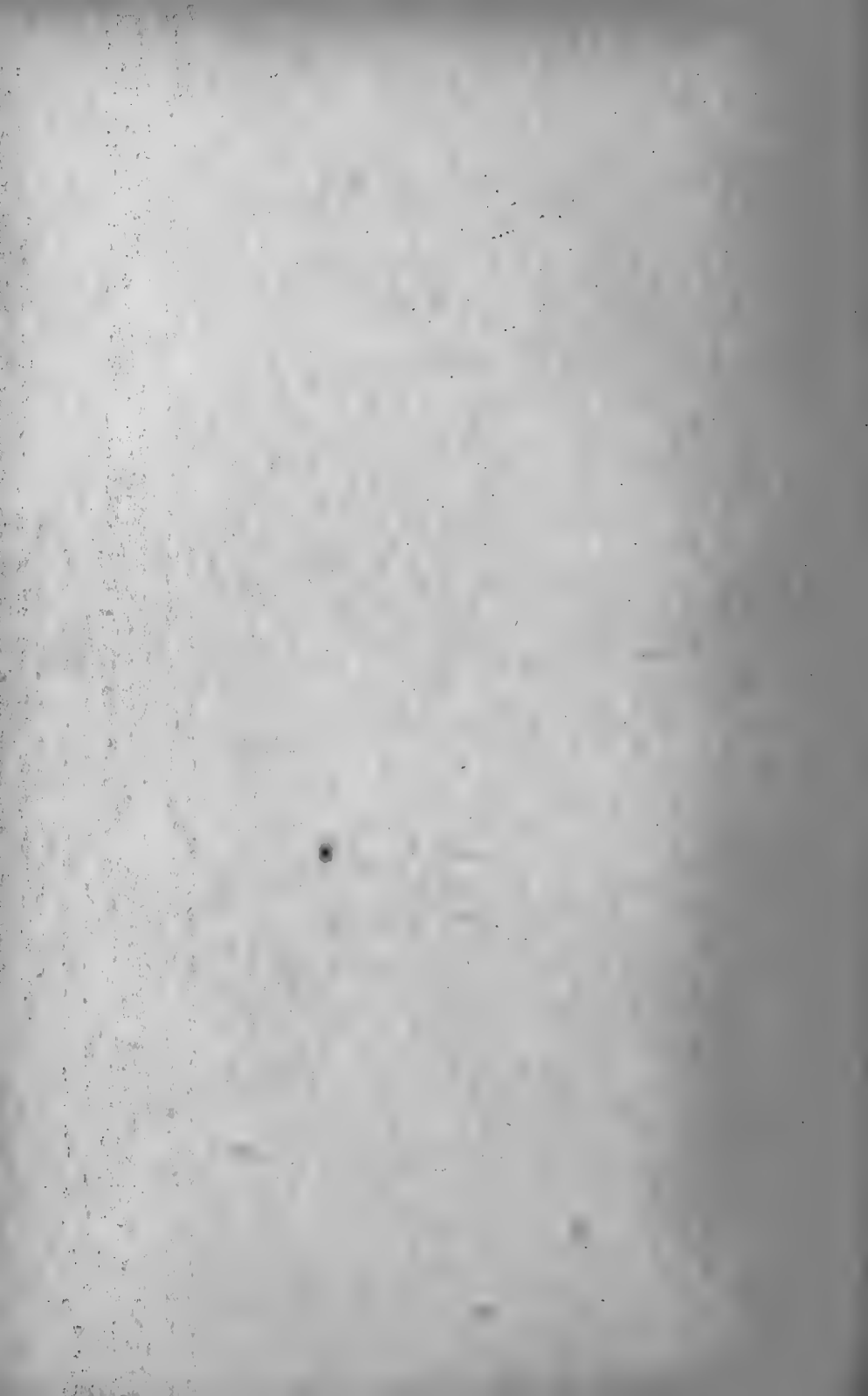
PLATE 7

Blastoidocrinus carchariaedens Billings (sp.)

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Figures a–o are of the under or inner surfaces of what the author has called apical or anal pieces. They show the gradual development of a depression (due to downward growth of the piece) which led Mr E. Billings to describe them as possessing a "central perforation." The oldest member of the series seems to clearly show the impression of five subtegmenal? plates of the peristome, the one in the lower interradius of the figure being displaced. Other figures, particularly l, show traces of the displaced plate and of the other plates.

Figures p, q and x are of outer surfaces. A four rayed piece is shown at g and a six rayed piece at x.

The remaining figures are of stem joints and of roots that may belong to this species.

The specimens figured are now in the New York State Museum.
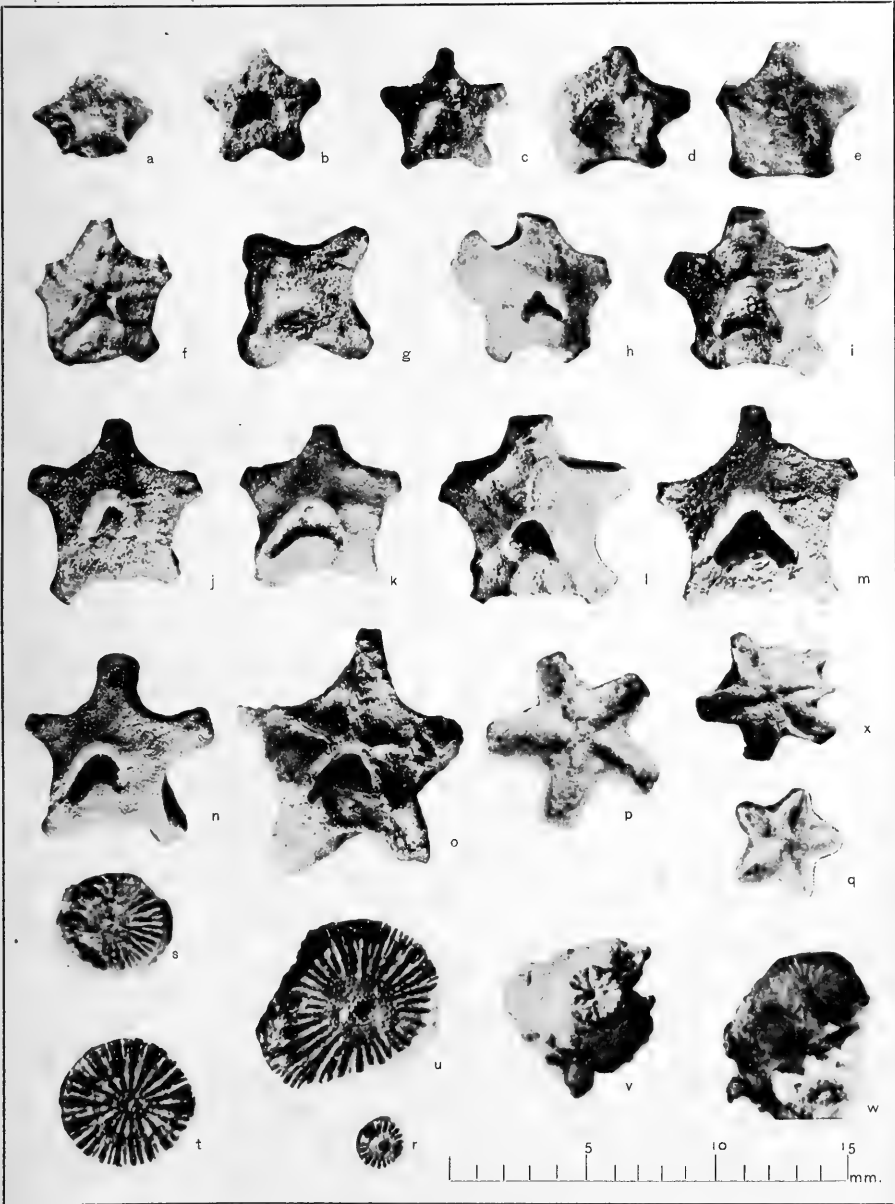
PLATE 8

Deocrinus asperatus Billings (sp.)

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Two views of the type of "R h o d o c r i n u s" a s p e r a t u s Billings. Most of the sutures and a few of the small plates of the tegmen were outlined on the photograph before reproduction.

The unique original is from the Chazy limestone and was found "in a quarry about 2 miles north of the city of Montreal." It is now in the Museum of the Geological Survey of Canada, at Ottawa.

L. post. R.

L ant. R.

5   10
mm
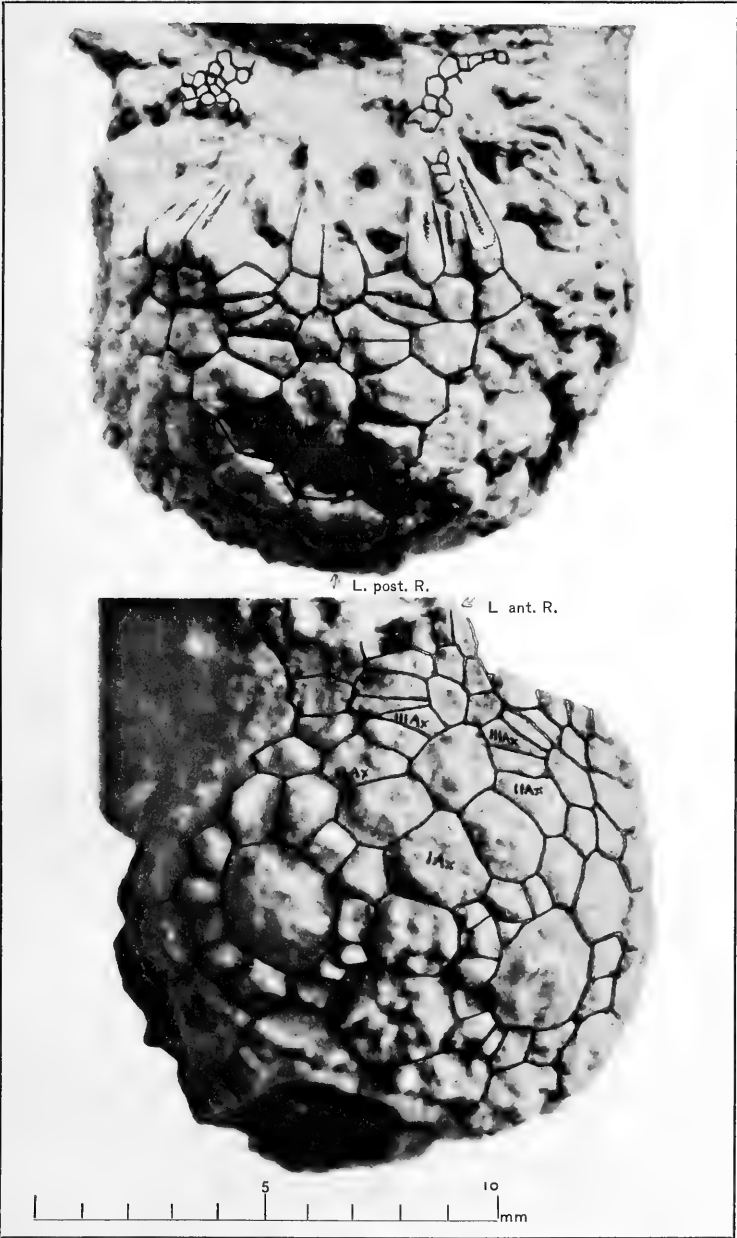
PLATE 9

Hercocrinus elegans sp. nov.

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Two views of the only specimen found. The base has suffered some displacement and one side has been crushed in. Some of the filled in material between the plates of the base has been indicated by cross hatching.
The specimen is from the same horizon that yielded the Blastoidocrinus and is now in the collection of the writer.
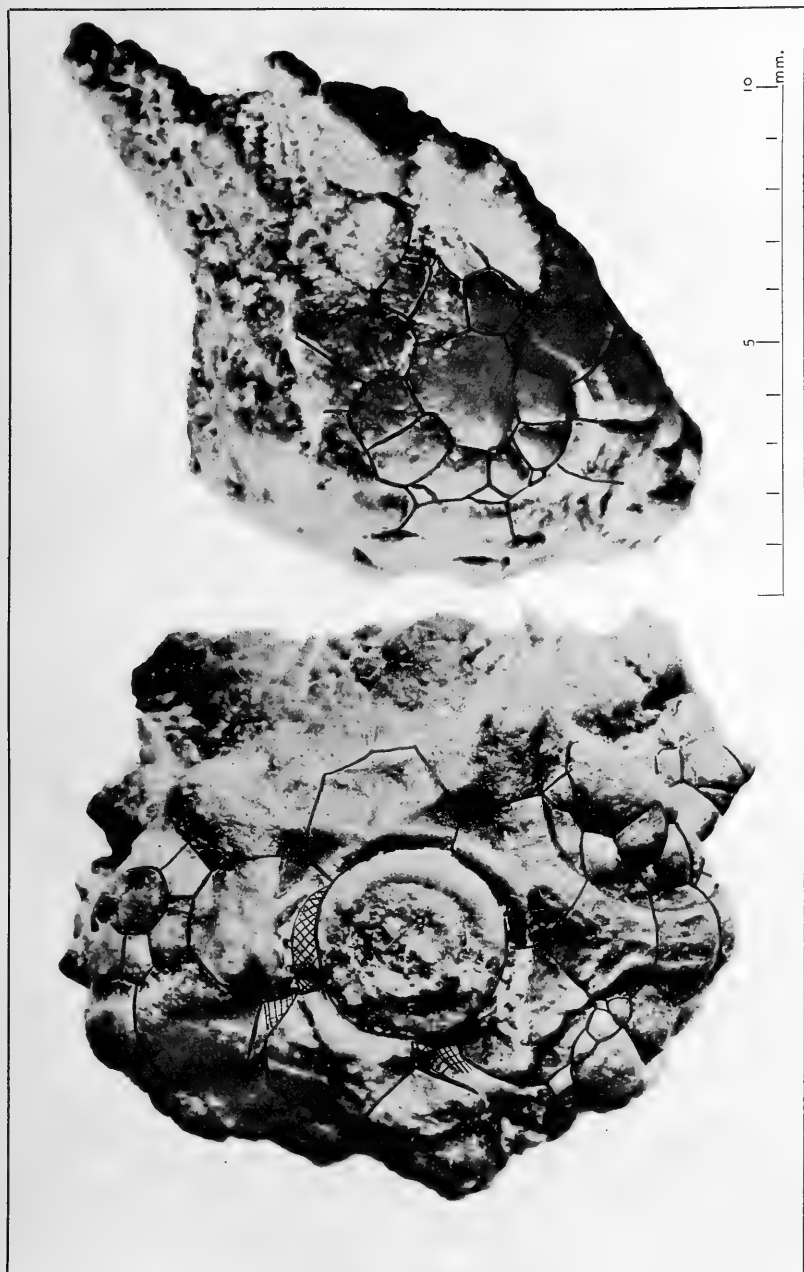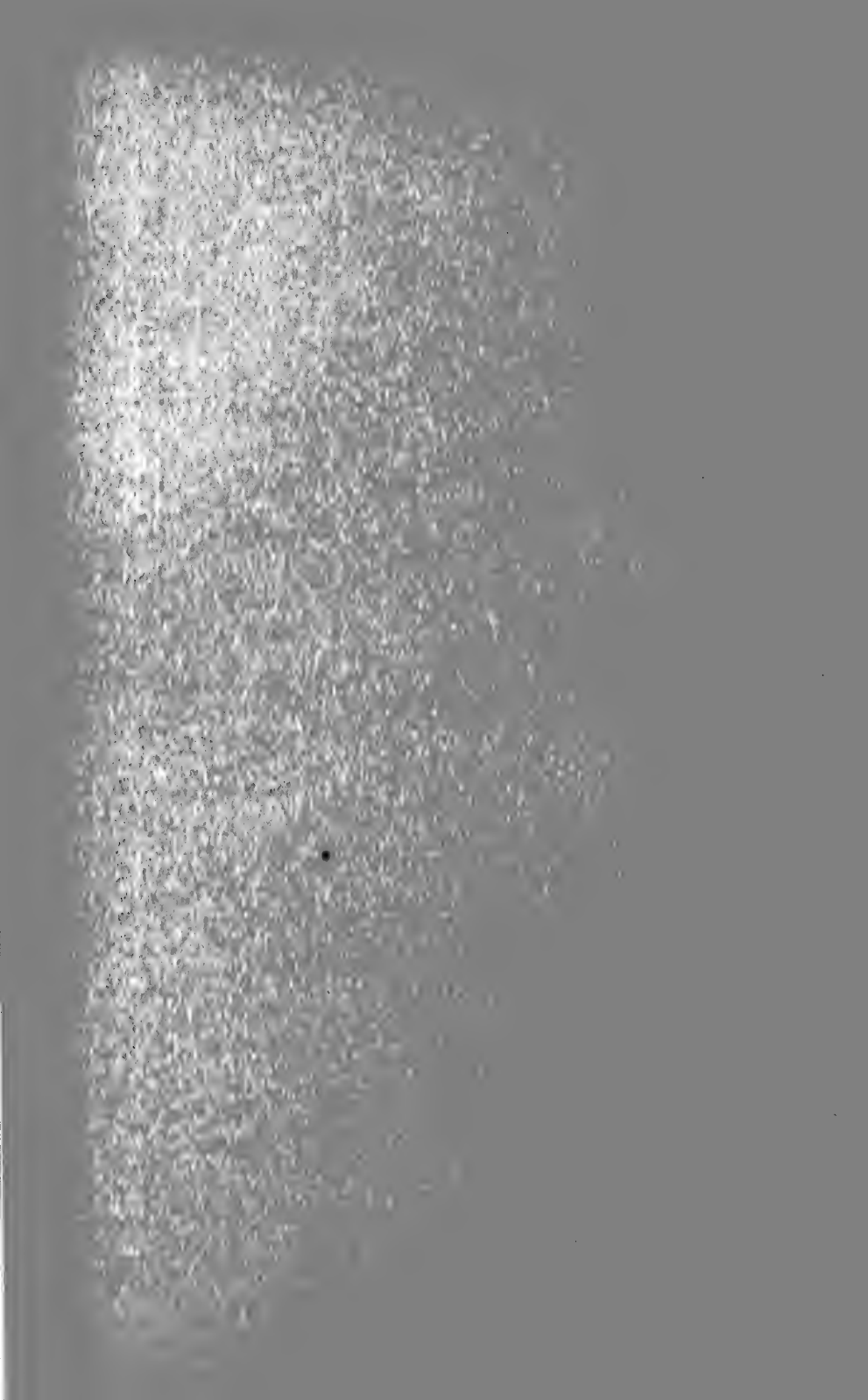
Plate 9

PLATE 10

Hercocrinus ornatus sp. nov.

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From a photograph of the only specimen found. A few sutures have been marked with ink to show them the more clearly.

The specimen is from the same horizon that yielded the Blastoidocrinus and is now in the collection of the writer.

SOME NEW DEVONIC FOSSILS

BY

JOHN M. CLARKE

Introductory note

It is not a customary procedure of the writer to issue preliminary reports on investigations in progress, but to insure some part of the results of labors extending over several years, it seems well to make exception in the present case by publishing the following notes on some of the Devonic fossils that have come under consideration during this time. Fuller accounts and more elaborate illustration of them will follow in proper time and without undue delay. These species are from the representatives of the New York early Devonic formations in Gaspé, Province of Quebec; Dalhousie, Province of New Brunswick; eastern and central Maine. It may be added that they are the incidents of a somewhat protracted study of features in the *Early Devonic Stratigraphy and Physiography of Eastern North America* and all are believed to be new to science.

TRILOBITES

Dalmanites griffoni nov.

In lobation of tail there is little to distinguish this species from D. m i c r u r u s Green, and the general outline of the head and of
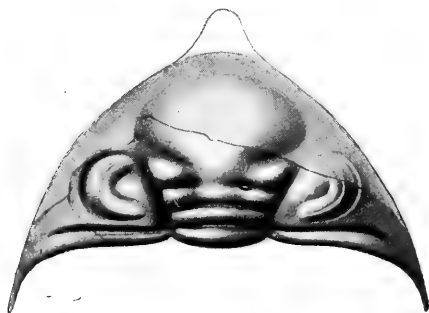
Dalmanites griffoni

the glabellar lobes is similar, but in excavating these fossils from the compact residual clay into which the rock at the locality

indicated has altered I observed and made note of a cephalon on the anterior limb of which was a very pronounced elongate and spatulate extension, as is represented in outline in our figure. This was so fragile that I was unable to preserve it and no other specimen of the cephalon was complete in this frontal region. It is such a prolongation or snout as one sees in Salter's figure of D. l o n g i c a u d a t u s [British Trilobites, 1864, pl. 3, fig. 19] from the Wenlock shale which one may regard as an incipient condition of the Probolium condition.

Lower Devonic. St Alban beds, Griffon Cove river, P. Q.

Dalmanites coxius nov.

This species is represented by a pygidium subequally triangular and distinctly flat with relatively narrow axis and broad sides. The margins have a slight outward curve and meet behind in a short broad caudal spine. The pleural ribs extend very nearly to
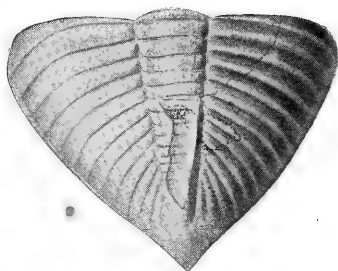
Dalmanites coxius

the margin and on the cast they appear to be elevated abruptly on the posterior edge and slope gradually from this edge upward. The same character is noticeable on the segments of the axis. The intervening grooves are thus not sharply defined except at their upper margins. There are 12 of these flattened shelving ribs on the pleura and 12 to 15 on the axis. Each of the pleural ribs shows trace of a fine surface groove. The test is very thin and its surface so far as known very finely granulated. The specimen has a length of 35 mm and a width of 44 mm. I should be at a loss for a known species with which to compare this tail. In respect to the character of its segments and its thin test it is like D.

l i m u l u r u s, the well known Upper Siluric species of New York, but therein the resemblance ceases.

Lower Devonic. Probably from Cape Rosier, P. Q.

Dalmanites dolbeli nov.

Certain cephala and pygidia which there are good reasons for assigning to each other present many points of resemblance to several well known species of the same subgeneric type. The lat-
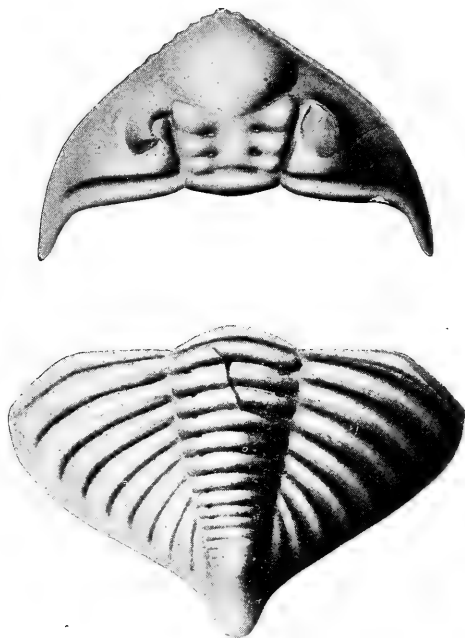
Dalmanites dolbeli

ter are D. p l e u r o p t y x of the New Scotland beds (Helder-bergian), D. s t e m m a t u s of the Oriskany and D. a n c h i o p s of the Schoharie grit. Generally speaking these four species are alike in the following respects: They are all forms which attain a large size, have notably short and broad cephala, with the first and second glabellar lobes fused distally and elevated to the eye lobe, frontal border with a row of crenulations at the edge, the more conspicuous being terminal, grooved eye base, faint if any groove along the lateral facial suture, and inosculating surface markings on the cheeks. The tails are broadly triangular and sparse ribbed ending in caudal spines not greatly extended.

By tabulating the differentials of these four species we shall indicate the features in which D. d o l b e l i is unlike the rest.

	pleuroptyx	stemmatus	anchiops	dolbeli
Cephalon	Short	Longer	Short	Short
Occipital ring	No spine	No spine	Spine	No spine
Confluent papillae on cheeks	Conspicuous	Inconspicuous	Inconspicuous	Inconspicuous
Suture line on cheek	Flush	Flush	Depressed	Flush
Pygidium Lateral ribs	11–13	9–10	8–9	8–9
Axial ribs	13–(15)	9–(11)	9–(14)	10–(13)
Ribs	Deeply grooved, rounded	Not grooved, rounded	Not grooved, rounded	Faintly grooved, rounded
Caudal spine	Short, acute, elevated axially	Broad, obtuse, not elevated axially	Slender, extended, upturned, not elevated axially	Broad, somewhat extended, upturned, blunt, and not elevated axially

Sharing its principal structures with the other three and separated from them by differentials which are of the same quality as those distinguishing other members of the series, D. d o l b e l i represents a notably early Devonic type of structure.

Dimensions. Cephalon: large examples attain an axial length of 40 mm and a width of 75 mm. Pygidium: an average example has a length of 40 mm and a width of 60 mm.

Lower Devonic. Grande Grève and Shiphead, P. Q.

Dalmanites lowi nov.

A very distinct type of structure is presented by a few pygidia which are of considerable size, relatively quite short, broad at the
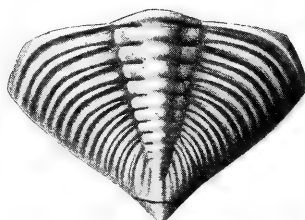
Dalmanites lowi

top, with pleural ribs 10 or 11 in number, the last three of which are simple and faint but all the rest very strongly duplicate throughout their entire extent becoming obsolete at or just within the margin. The axis is broad and the dorsal furrows rapidly approx-

imate; it bears 11 or 12 segments and its apex is not abrupt but merges into a low median ridge continued to the end of the tail. The terminal spine is little more than a broad and short rather obtuse expansion. The surface of the test is finely granulate except for a few scattered coarser pustules on the axis. The specimens average 26 mm in length and 29 mm in width.

This style of pygidial structure with strongly bifurcate pleural ribs is represented in the faunas of the early Devonic elsewhere by such species as D. b i s i g n a t u s Clarke (Oriskany) and D. d e n t a t u s Barrett (Oriskany). It is probable that the cephala of all have a crenulated or dentate border as D. d e n - t a t u s and its associate D. d o l p h i Clarke are known to have.

Lower Devonic. Grande Grève and Indian Cove, P. Q.

Dalmanites perceensis nov.

The parts found of this species are separated pygidia and cranidia. In the latter the frontal lobe is gently rounded and depressed; the first and second lateral lobes well fused at their extremities; the surface of the frontal lobe coarsely papillose. The
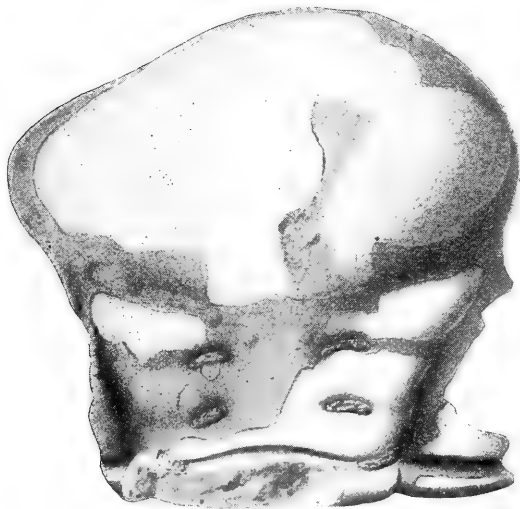
Dalmanites perceensis

pygidium is broadly triangular, but little arched at the sides; the lateral margins rounding in full curves and the tail spine short, acute and upturned; the axis has straight regularly converging dorsal furrows and its width is less than two thirds the width of each pleura. It bears 18-20 broad flat directly transverse annula-

tions with very narrow furrows. The fourth and eighth annula-
tions bear two strong nodes on the axis and the 9th, 12th
and 13th show fainter traces of them. The broad and flat
pleurae bear 15-17 flat ribs grooved by narrow and sharply incised

Dalmanites percensis
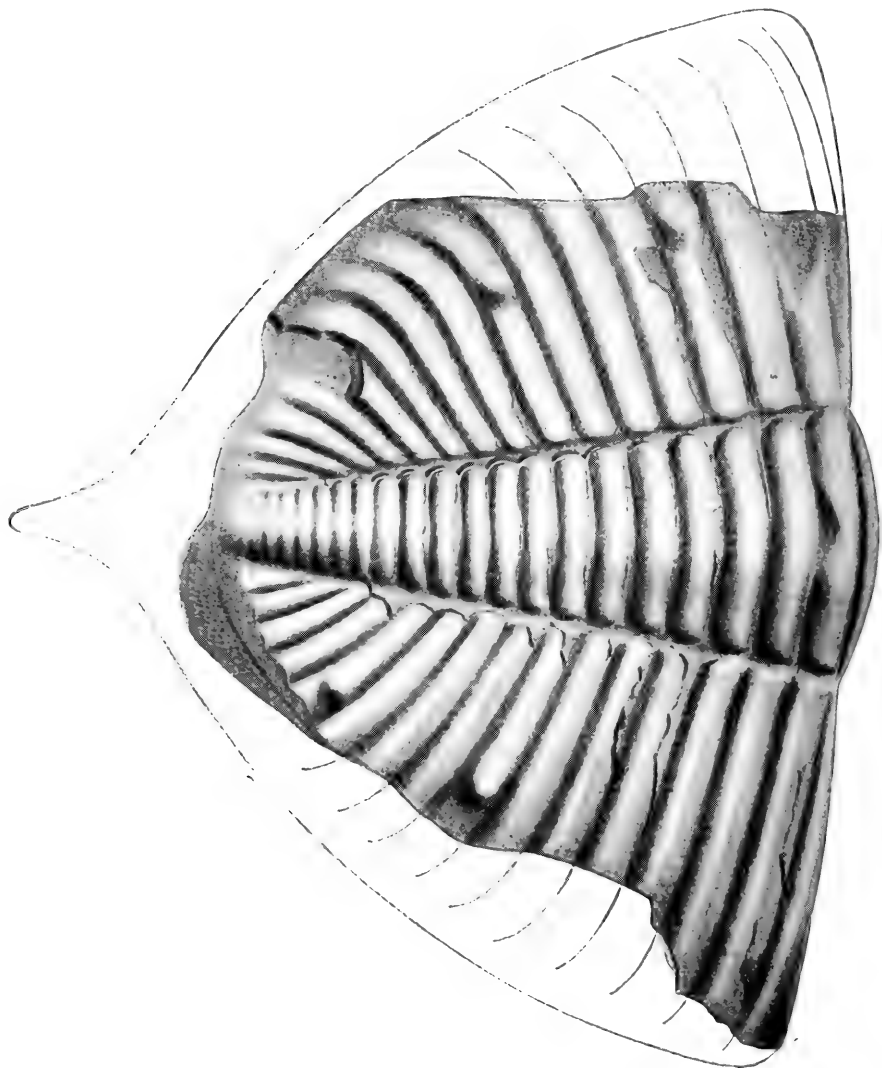
oblique furrows; the ribs bend abruptly backward near the margin
and are discernible almost to the edge of the shield. They are also
sparsely but very irregularly nodose, the nodes being large and
coarse. The whole surface is finely granular.

Lower Devonic. Percé rock, P. Q.

Dalmanites veiti nov.

Associated with specimens of D. p h a c o p t y x from the lime-stone hills behind Peninsula. Gaspé Bay, are abundant pygidia and cephala of uniform size, unlike the species with which they are associated as well as with any others of our acquaintance. These pygidia are relatively small, subequally triangular, flattened above and rather abruptly sloping at the margins; apparently without tail spine. There are 11–12 lateral ribs, 6 or 7 of which are grooved medially. The axis bears 13–14 segments. The upper limb of each of the divided lateral ribs carries 2, 3 or 4 pustules so devel-
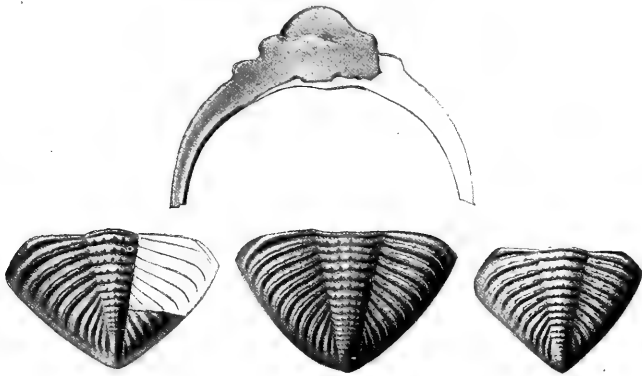
D a l m a n i t e s v e i t i. The underside of the cephalic doublure x2 and three pygidia natural size

oped as to overhang the sulcus, while each segment of the axis bears a single row of 5, 6 or 7 pustules. The length of these shields will average 23 mm with an anterior width of 29 mm.

The cephala belonging to these pygidia are not completely preserved but indicate a type of simple glabellar lobation as in D. m i c r u r u s, with closely pustulose surface. The border is smooth laterally but in front is extended into a short crenulated snout or shelf as in D. p l e u r o p t y x and D. d o l b e l i though less expanded at the sides than in either of these.

There is undeniable similarity between this fossil and the D. b i-s i g n a t u s described by me from the Oriskany of Becraft mountain.[1] The latter, known only from the pygidium, has the part narrower and more elongate and its axial pustules are so arranged as to make a longitudinal median double row. That species we have noted (*op. cit.*) is allied to D. d e n t a t u s Barrett from the same horizon in Orange county, N. Y. but in ignorance of the cephalon of the

[1] N. Y. St. Mus. Mem., 3. p. 19, pl. 2, fig. 6–8.

former, comparison can go no farther. D a l m a n i t e s v e i t i
has a type of cephalon quite unlike that of D. d e n t a t u s which
is dentate on the entire periphery.

Locality. This species has been found only in a loose block from
the limestone ridge behind Peninsula, Gaspé Basin, in association
with D. p h a c o p t y x , P h a c o p s l o g a n i g a s p e n s i s ,
P l a t y c e r a s c o n u l u s , A n o p l i a n u c l e a t a and other
species of the Grande Grève fauna.

Lower Devonic. Grande Grève, P. Q.

Dalmanites whiteavesi nov.

This species is represented by a series of small pygidia some-
what of the type of that part in D. a n c h i o p s Green but more
particularly like that of D. m e e k i , figures of which may be found
in Walcott's *Palaeontology of the Eureka District,* 1884, pl. 17, fig.
5, and *Palaeontology of New York,* 1888, v. 7, pl. 11A, fig. 29, 30;

Dalmanites whiteavesi

that is, rather short and subtriangular but with rounded margins and
an extended, slender caudal spine. The axis is moderately broad
and convex bearing seven or eight segments which are well rounded
and the pleural ribs are of the same number, flat on top with narrow
intervals and each is grooved by a fine line.

The margins of the shield curve slightly outward uniting behind
to form a spine which has about one fourth the length of the shield.
It is narrow, ends acutely and is slightly upturned. As a whole
the shield is shorter, relatively broader and has more segments than
does D. m e e k i. The latter is from the lower part of the Devonic
series in Nevada.

Lower Devonic. Grande Grève, P. Q.

Dalmanites gaveyi nov.

We are here presented with a species in which the frontal margin
of the head bears a slight, simple, lobed and blunt extension with-
out accessory processes or crenulations similar in effect to that of
D. g r i f f o n i. This is a structure after the type of D. v i g i l a n s

Hall and D. l i m u l u r u s Conrad of the Niagaran, of which a simple, well lobed structure of the glabella is an accompaniment.

This species has been observed in several examples, has a rather short cephalon in which the glabella is subpentagonal, the dorsal furrows not deep and rather obscure at the outer ends, the frontal lobe highly transverse, right short, and merging directly into the frontal extension. The glabellar furrows are very obscure, the first and second lobes but ill defined, slightly swollen and club-shaped but the third lobes are linear and are better defined. Eyes
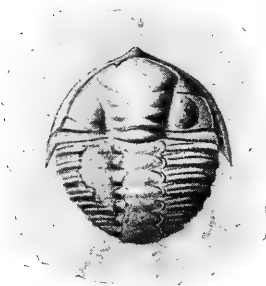
Dalmanites gaveyi

comparatively small and not sulcate at the base, cheek spines very narrow and produced. The cheeks slope somewhat abruptly to a thickened and rounded edge without border. The surface is marked by no noticeable pustules but by a fine granular ornament. This is a very distinctive and rather rare type of structure expressed not so much in the frontal projection as in the somewhat swollen aspect of the glabellar lobes and the obsolescence of the furrows, as well as the smoothness of the surface.

Dimensions. Length 12 mm, width 23 mm. One of the specimens carries a considerable part of the thorax but the pygidium of this species is not yet identified.

Lower Devonic. Grande Grève, P. Q.

Dalmanites ploratus nov.

There is a group of tuberculated dalmanites in the early Devonic rocks, embracing D. d e n t a t u s Barrett (which the ornament of the cephalon shows to be a Corycephalus), from the Port Jervis Oriskany, the allied D. b i s i g n a t u s Clarke and D. p h a c o p t y x H. and C. from the Becraft mountain Oriskany. Of the last two the pygidium of the former is a shield of slender propor-

tions with regularly widened tubercles on the axis, in the other it is large and has coarse irregularly scattered tubercles. The pygidium before us is of the general type of D. b i s i g n a t u s but is larger and considerably more segmented. Thus D. b i s i g n a t u s has 7-8 pleural ribs while D. p l o r a t u s has 15-16, the former 10-12 axial rings, the latter 20-22. Notwithstanding this difference there is a similarity in the size and arrangement of the tubercles or
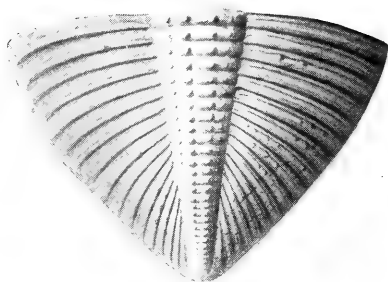
Dalmanites ploratus

granules; on the annulations there is a single row of four of which the middle ones are largest. Passing to the apex of the spindle this middle pair becomes more conspicuous by the disappearance of the others and thus there appears to be a double axial row of these pustules. On the pleurae they are scattered irregularly and faintly over the sulcate ribs. Our specimens do not show whether or not the caudal extremity ends in a spine.

Lower Devonic. Loose at Cunningham's camp, 4 miles below Matagamon lake, Me.

Dalmanites (Probolium) biardi nov.

P h a c o p s   w e a v e r i? Salter. Silurian Trilobites. 1864. p. 57, fig. 15

Cephalon broadly subelliptical in outline, short axially, like the prevailing type in contemporaneous faunas (D. a n c h i o p s, p l e u r o p t y x, s t e m m a t u s, n a s u t u s, t r i d e n s). Glabellar division normal but the usual fusion of lobes 1 and 2 at their distal extremities which affects so many of the early Devonic species of Dalmanites, is not strongly expressed and herein again there is agreement with D. (P r o b o l i u m) n a s u t u s and t r i-d e n s. Margin entire except near the anterior extremity where there is a series of broad low scallops or crenulations, three or four in number on each side of the snout. These are so obscure

that they are seldom seen except on casts of the ventral surface of the border and in such cases the outermost sometimes assume the aspect of a pair of subsidiary spines. The snout is axial, has a broad base, is contracted in diameter medially and at the distal extremity carries a trident the central process being axial, the other two diverging palmately and all considerably extended. There seems to be some variation in the length of this process but apparently it was from one third to one half as long as the cephalon itself. The entire process is flat. In the trilobed species of the
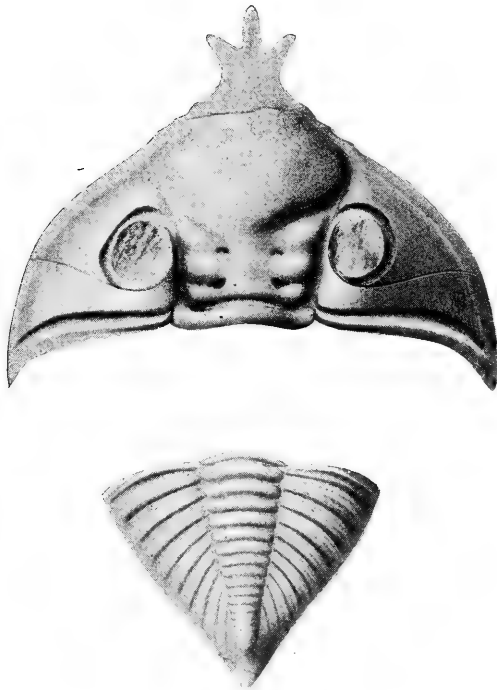
Dalmanites (Probolium) biardi

New Scotland beds, D. t r i d e n s, there is likewise noticeable variation in respect to the development of these processes as shown by the figures given in *Palaeontology of New York,* v. 3, 1859, pl. 75, fig. 3–6; it sometimes has them so much reduced that the extremity takes on a spatulate outline. The genal spines are relatively broad and short. The surface of the cheek below the visual area is deeply grooved, the facial suture on the cheeks does not lie in a furrow and the surface below the eyes shows only rather obscure traces of confluent papillae. The general surface

is rather finely pustulose especially on the cheek spines. The thoracic segments show no features that can be regarded as distinctive.

Pygidium. Elongate, subequally triangular, subacuminate, of the general type of D. m i c r u r u s and less like the nodose surface with long tail spine characterizing D. (P r o b o l i u m) n a s u t u s. Axis relatively narrow, segments 10 to 12. Pleural ribs 9 to 10, flat above, grooved by a fine line and separated from each other by rather narrow furrows. Caudal termination a broad and short, acute and slightly upturned spine. Surface finely granulose on the ribs and along the margins with obscure evidence of low faint nodes.

Dimensions. The average of our specimens indicates a length of cephalon not including the snout, of 30 mm, a width of 63 mm. In such a specimen the snout would have a length of 16 mm with a spread from tip to tip of the lateral spines of 12 mm. An average pygidium measures 36 mm in length and 42 mm in width.

Lower Devonic. Percé rock and Blowhole cliffs, P. Q.

Dalmanites (Probolium) esnoufi nov.

A quite imperfect cephalon in general features has the aspect of the shields referred to D. m i c r u r u s Green, the border being broad, flat and smooth at the edge, the frontal lobe of the glabella transverse and rather narrow, the other lobes quite small but the

Dalmanites (Probolium) esnoufi

first two lobes are fused at the outer edges. The genal spines are produced, the eyes furrowed at their base and the groove within the border is conspicuous. The border in front is produced into a bifurcate process, the branches of which are flat, very divergent and rise from a broad base.

The aspect of the cephalon before us is very unlike that of D. (P.) b i a r d i in the various details referred to. D a l m a n - i t e s (P.) n a s u t u s Conrad[1] is a bifurcate species in the Helderbergian (New Scotland beds) of New York, which has more in common with P. e s n o u f i, specially in its smooth border, but the base of its snout is very much more elongated and its branches slender and cylindrical. The specimen measures in length, from tip of snout 32 mm, from front of glabella 23 mm and in width 50 mm.

Lower Devonic. Grande Grève, P. Q.

Phacops logani Hall var. **gaspensis** nov.

The species of Phacops very common in the Grande Grève limestones presents itself in all variations of size. The larger forms are coarsely tubercled on the glabella and in these there is a well defined row of knobs on the thoracic axis along the dorsal furrows, shown always to best advantage on the internal cast. The pygidium
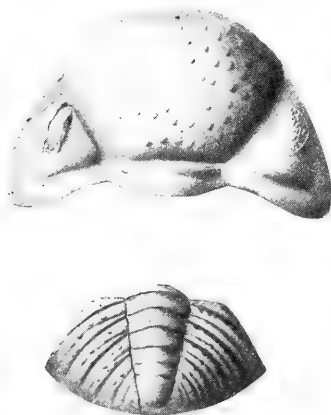
Phacops logani var. gaspensis

has four to five duplicate lateral ribs. Added to these critical features is the absence of genal spinules. The larger of these forms have a close and distinct resemblance to the species described by Hall as P. b o m b i f r o n s[2] from " the limestone of the Helderberg mountains," by which was intended that now known as the Onondaga limestone, a resemblance expressed in all the characters of the cephalon which carries a full bombate glabella. We have

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[1]Palaeontology of New York, 3: 362, pl. 76, fig. 1–8.
[2]Descriptions of New Species of Fossils. 1861. p. 67; N. Y. State Cab. Nat. Hist. 15th An. Rep't. 1862. p. 95; Illustrations of Devonian Fossils. 1876. pl. 6, fig. 22–24, 29.

no means of knowing the other parts of the animals thus designated by Hall.   In the Grande Grève rocks these large, coarsely tubercled cephala have the thoracic segments knotted at the dorsal furrows as in large specimens of Ph. l o g a n i.   In smaller specimens these thoracic characters are obscured except in the cast, but the cephalic shields of the latter do not show the spinules of the Percé species and of typical P. l o g a n i.

The variations of expression in the representatives of the genus Phacops in the New York Devonic are slender and identifications are always obscure.   Fixing upon the following characters as critical, viz, the cristation of the genal angles, the knotting of the thoracic segments and the grooving of the pleural ribs on the pygidium, we may tabulate the species thus:

	Cheeks	*Thorax*	*Pygidial ribs*
P. l o g a n i (Helderbergian)	faintly spined	knotted	duplicate
P. c r i s t a t u s (Schoharie grit)	strongly spined	smooth	duplicate
P. c r i s t a t a var. p i p a (Onondaga)	faintly spined	smooth	duplicate
P. b o m b i f r o n s (Onondaga)	smooth	smooth	duplicate
P. r a n a (Hamilton-Ithaca)	smooth	smooth	simple

In this schedule the Grande Grève species takes a place close to P. l o g a n i; the Percé form, which is always small, is a near approach to the typical expression of the species.

Lower Devonic.   Everywhere along the Florillon from Shiphead to Little Gaspé, and in the blocks of limestone from the second range found in the stream bed at Peninsula.   Also at the Ruisseau du Grande Cavée associated with D a l m a n i t e s g r i f - f o n i, and in Percé rock, P. Q.

Phacops (Phacopidella) nylanderi nov.

This is an addition to the peculiar group of early Devonic species of which we recognize the following other members: P. b r a s i l - i e n s i s (Maecurú), P. a n c e p s (Decewville), P. c o r r e l a t o r,
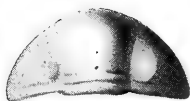
Phacops (Phacopidella) nylanderi

New York Oriskany and Gaspé sandstone.   We have noted in what respects this group departs from the structure presented by P. d o w n i n g i a e, the exemplar of the generic group Acaste=Pha-

copidella Reed. The material from this locality has afforded but a single cephalon of small size with semicircular outline, rotund but not protuberant glabella, in which all glabellar lobes are extinct save that at the base which takes the form of a narrow and obscure ring. The preservation here is without compression which in some of the other species of the series serves to indicate the glabellar furrows. The nuchal ring is elevated, the eyes relatively large, and the small cheeks are apparently produced into short genal spines. The length of this specimen is 4 mm and its full width 8 mm.

No indications of other parts that can be referred to this species are present.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Bronteus barrandii Hall var. majus nov.

A pygidium with the structural details of B. b a r r a n d i i, but having many times the size distinctive of that species in New York and Gaspé. It has the short axis, broad median rib and
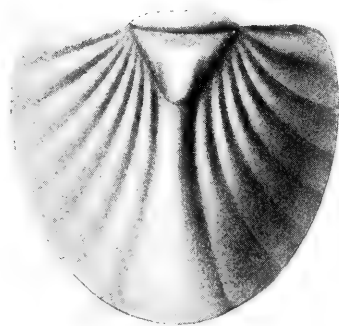
Bronteus barrandii Hall var. majus

seven lateral ribs on each side, all becoming obsolete on the smooth border. There is here no variation from the specific type but a noteworthy distinction in expression.

Lower Devonic. Stewart's cove, Dalhousie, N. B.

Lichas (Gaspelichas) forillonia nov.

The several parts of this species found are, on account of the great spines, intricately complicated with the matrix and it has been possible to extricate them only at the cost of infinite labor and

patience. The species is not common and our specimens represent
three cranidia with separated cheeks. The general type of cephalic
structure irrespective of the spines is practically that normal to
such typical expressions of Lichas as seen in Arges, Ceratolichas,
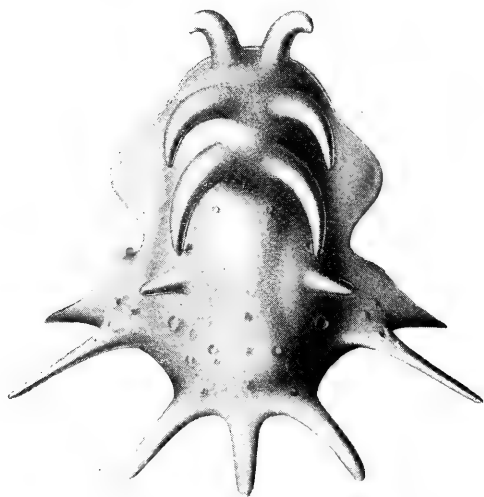
Lichas (Gaspelichas) forillonia

Hoplolichas and Conolichas, the frontal lobe being large, ovoid
and prominent, not set off by deep lateral grooves as in Terataspis
but most prominently elevated posteriorly. The lateral lobes are
long and narrow, subcrescentic in form and but very slightly ele-
vated so that the surface between the dorsal furrows is low, gently

convex and very long, terminating posteriorly in a more elevated triangular area. The prevailing aspect of the cranidium and glabellar lobes is that of narrowness and length, particularly in the distance between the nuchal furrow and the frontal lobe. The nuchal furrow is broad and low and the occipital ring broad, flat and arched.

Spines. While the general surface is tubercled and some of the tubercles become developed into short spines the major spines are as follows: three pairs, one in front of another on the crest of the glabella; these are of great size and strength and deeply curved backward. They seem to be all of about the same length. In some of our specimens the posterior pair curves backward in a long arch to and beyond the posterior margin of the head, but in a younger specimen they are shorter. The middle and anterior pairs are quite as long. In section these great frontal spines or hooks are not circular but somewhat flattened on the opposing faces though rounder on the outer surface and narrow fore and aft.

On each lateral lobe where widest, and just above the dorsal furrows, is a spine of less hight than the foregoing and apparently erect and these are flanked in front by a much shorter pair. These five pairs seem to be all there are on the glabella except for the spinous tubercles in the occipital area.

The occipital ring bears at its edge on the axis a series of long curved flat or vertically compressed spines, one at the middle and one diverging from the axial spine, at each side. These are neither as long nor as large as those of the frontal lobe but they must have reached back over several of the thoracic segments. The occipital ring is deeply contracted at the dorsal furrows and where it expands again beneath the cheeks it extends out on each side, into a flat but straight and slender spine larger than the others. This makes five spines on the neck ring, 15 in all on the cranidium, seven pairs and one axial. It would be natural to expect others on the palpebral lobe but these seem to be wanting.

The other parts of the species are represented by portions of free cheeks which indicate that these ran out into short, thick and narrow genal extensions with a row of rather small spines along the occipital margin, while just outside of the eye near the margin there was a very large, long and recurved hook like those of the frontal lobe. There is still some uncertainty as to the exact details

of these parts, due in large measure to the difficulty of extracting them from the rock.

Dimensions. The largest of the specimens affords the following measurements: Probable entire length to top of axial spine, 90 mm; length of posterior glabellar spine (not restored) 41 mm; on the curve, 55 mm; greatest vertical hight of anterior spines (not restored) 30 mm; length of lateral occipital spines, 27 mm; vertical hight of spine on cheek, 30 mm. These figures indicate that the species is one of the largest as well as the most extravagantly ornamented of all forms of Lichas. It is surpassed in dimensions only by T e r a t a s p i s   g r a n d i s and U r a l i c h a s   r i b e i r o i, the lords of this tribe. Equipped with cerements of mortality, successors of this genus Gaspelichas are not to be expected.

Lower Devonic. Grande Grève, P. Q.

Lichas bellamicus nov.

This is a species of medium dimensions having the lobation of cephalon and the outline of the pygidium very similar to the corresponding parts in the prevalent forms of Lichas from the Helderbergian.

The frontal lobe is pyriform, not elevated or bombate but uniformly convex, without abrupt posterior slope; the lateral furrows
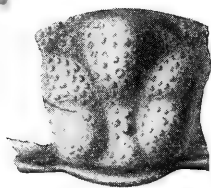
Lichas bellamicus

are deep and the converging lateral lobes elongate, of about equal width throughout and divided only by an extremely faint cross furrow. The grooves dividing these outer glabellar lobes forming the fixed cheeks are very shallow, and these cheeks are convex and elongated about the eye lobes. The cephalon appears to be bounded by a smooth margin which is flat in front. The entire surface except the furrows is coarsely tubercled and it would

appear that some of the tubercles at the crest of the frontal lobe are extended into thick spinules. Parts of a pygidium indicate that this organ was flat and extended and the margin carried long flat spines.

Lower Devonic. Grande Grève, P. Q.

Ceratocephala robinia nov.

This form is known from various parts and one nearly entire specimen, which attains much larger proportions than C. t u b e r -

Ceratocephala robinia

c u l a t a (Helderbergian) and yet is allied to both that species and the C. c a l l i c e p h a l a from the Onondaga limestone. Placing these species in comparison we may find the distinctive characters expressed as follows:

	C. t u b e r c u l a t a	C. c a l l i c e p h a l a	C. r o b i n i a
Size	Small	Medium	Large
Neck ring	With short stout spine	With small spine	With longer, stout and somewhat curved spine
Thoracic segments	Finely tubercled	Regularly and coarsely tubercled	Coarsely tubercled
Pygidium 1st spines	Moderately long	Slender and longer than 2d pair	Very short
2d spines	Much longer	Shorter than 1st pair	Longer than 1st pair
3d spines	Large, stout and twice the length of 2d pair	Not conspicuously the largest of the series	Sharp and slender, longest
4th spines	Very short	Relatively long and slender	Sharp and slender, more than ½ the length of 3d pair
Surface	Strongly tubercled	Tubercled	No tubercles

These differences will be found to pertain chiefly to minor features but we conclude that there is in the Gaspé specimens a distinction from these allies in time and structure which is clearly defined and significant in the interpretation of these faunas. It is not at present possible to say whether the New York Oriskany species is of the same type.

Dimensions. The only specimen which we have observed having the parts together is in the Redpath Museum of McGill University. We owe to Prof. F. D. Adams the opportunity of studying this example. It is from Grande Grève and has a length of 20 mm. Cranidia of other specimens are of about the same size.

Lower Devonic. Grande Grève and Percé rock, P. Q.

Cordania gasepiou nov.

Body small, oval, cephalon with ovoid coarsely tubercled glabella and small basal lobes, small and highly elevated eyes beneath which the cheeks are excavated and concave and the anterior limb also concave and broad, bordered by an upturned thickened rim; genal
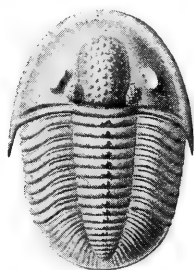
Cordania gasepiou

angles extended into slender spines reaching more than two thirds the length of the thorax. There may be a spinate tubercle on the neck ring but this has not been fully determined. The thorax has segments which are crested in the axial line by a row of spinules apparently increasing somewhat in length posteriorly and the lateral moieties of the segments are finely pustulose. The pygidium has

a strongly elevated axis and the median spines are higher and more recurved than those of the thorax. The pleurae are depressed convex and about the margin concave without a marginal rim. The pleural ribs are distinctly duplicate and equally so near the margin. All the pygidial ribs carry fine tubercles. The length of an entire specimen is 11 mm, width 9 mm.

Lower Devonic. Lehuquet's Cove, The Forillon, P. Q.

ANNELIDS

Tentaculites leclercqia nov.

Shells having very much the configuration of T. g y r a c a n-t h u s Eaton,[1] occurring, like that, in aggregations in the limestone, but uniformly of very much greater size. The slender cones, attaining a length of 10–15 mm, are strongly annulated but the
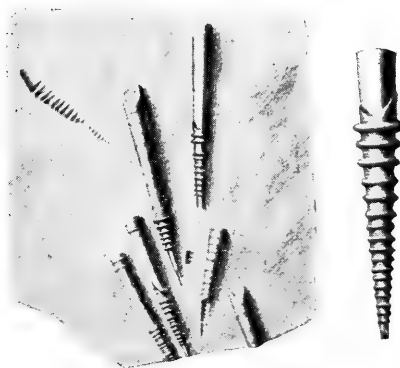
Tentaculites leclercqia.
The slab x2: the individual x5

annuli are often highly irregular in size and have an abrupt or concave slope on the lower side and a convex slope above. They are themselves covered with fine concentric elevated lines. The annuli appear to extend to the tip of the shell.

Lower Devonic. Percé rock, P. Q.

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[1]See Hall. Pal. of N. Y. 1859. 3:137, pl. 6, fig. 22, 23 (T. i r r e g u l a r i s); and *idem.* 1888. v. 7, suppl. pl. 104, fig. 7–13.

Tentaculites cartieri nov.

This is a large species with regularly annulated growth in early stages only but with increase in size the annulations become variable and of obscure outline, all the surface annulations and furrows alike being crossed by very fine regular and equal concentric lines, so that in respect to compression it is not remote from the Oriskany
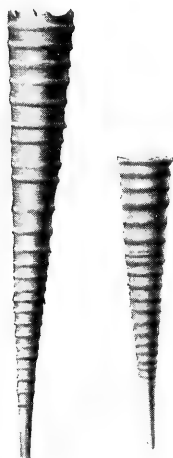
Tentaculites cartieri
The larger x2; the smaller, x3

species T. elongatus. The internal cast bears the usual conformation, suggesting a series of inverted and insheathed cones.

These shells attain a length of 35–40 mm with an apertural width of 4 mm.

Middle Devonic. Gaspé Basin, P. Q.

Tentaculites scalaris Schlotheim

Tentaculites scalaris Schlotheim. Petrefaktenkunde, p. 377, pl. 20, fig. 8, 9; *et auctorum*

There are no evidences of distinction between specimens of Tentaculites found in the Chapman Plantation and this well known Coblentzian species. Our specimens bear the strong rounded

annulations, subject to very slight variation with some irregularity in the intervals and these annulations are covered with fine concentric lines.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

CEPHALOPODS

Cyrtoceras albani nov.

This quite common shell has a long slender and gently curved cone, broadly swollen on the body chamber and constricted behind

Cyrtoceras albani

the aperture. The greatest curvature is in the later parts of the shell, the earlier portion being quite straight for a short distance.

The septa are regularly concave and close together, the surface ornamented by very fine elevated threadlike eccentric lines. The species is not unlike the C. s u b r e c t u m Hall of the Helder-bergian, whatever generic form that may prove to be when better known.

Lower Devonic. St Alban beds, Cape Rosier Cove, P. Q.

Kionoceras rhysum nov.

Straight longicones with regular narrow, erect annulations which may be slightly oblique and are separated by broad, smooth, con-

Kionoceras rhysum

cave or flat interspaces. On the best preserved external casts there is no trace of either longitudinal or concentric lines but the summits of the annuli are dotted or punctured.

This form is represented by specimens for the most part small, in which there are on the average six annuli in a length of 20 mm

but other examples indicate that the species attained large proportions.

Lower Devonic. Grande Grève, P. Q.

Kionoceras champlaini nov.

This species is represented by large cones having a series of low and broad undulations of the surface continuing quite to the aperture and these are crossed longitudinally by elevated, distant, simple
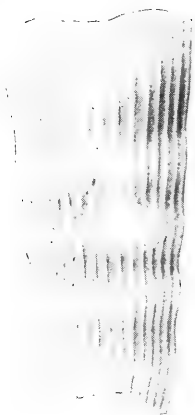
Kionoceras champlaini

lines with broad flat interspaces, each about 25 in number, the former becoming obsolete at the aperture.

This species is of rare occurrence and its characters distinctive. The best preserved specimen has a width of 22 mm at the aperture and a length (incomplete) of 50 mm.

Lower Devonic. Grande Grève, P. Q.

Orthoceras norumbegae nov.

A robust shell of which we have about six inches of the final part, retaining the surface sculpture. The shell seems to have tapered gradually and to possess a circular section. The fragment at hand has a length of 165 mm, a width at the top of 75 mm, at the bottom of 60 mm. The sculpture

consists of incised vertical lines at irregular intervals, making very flat and low elevated striae, some broad, some very narrow and threadlike, all rather wavy and irregular in their course, large and
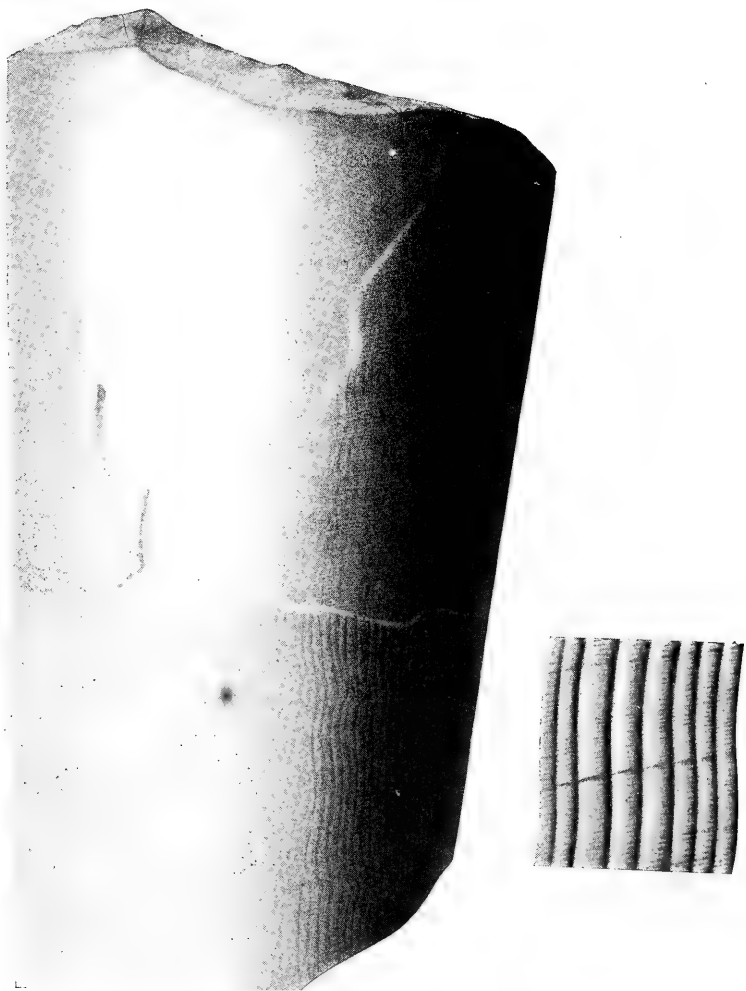
Orthoceras norumbegae

small interspaced without order. At wider intervals are deeper longitudinal sulci. All are crossed by faint and irregularly distributed concentric lines. This style of exterior is highly unusual and quite peculiar.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

PTEROPODS

Hyolithus richardi nov.

Shell large, tapering gradually; ventral face flat or slightly concave; dorsal face highly arched, subcarinate axially; apertural margin not produced on either face. Semioval in transverse section, apertural diameter to length as 1 to 3.5. The shell is slightly arched axially, the margins and the dorsal face being correspondingly incurved. The ventral surface is marked by very fine lines
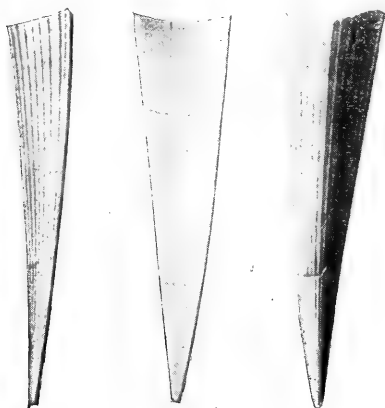
Hyolithus richardi

concentric to the slightly reentrant curvature of the margin; these are not crossed by vertical lines except those of structure, but the axial area may be flat and its boundaries present the aspect of vertical lines or depressions.

The opposite or arched surface bears a series of rather coarse subequal vertical ridges separated by flat and broader intervals. Near each margin is a deeper groove; obscure concentric striae are also preserved on this surface. The apertural margin of this face is slightly inflected.

Length of average specimen 35 mm; apertural diameter 8 mm.
Lower Devonic. Grande Grève, P. Q.

Hyolithus oxys nov.

Shell usually larger than the foregoing and relatively much broader, margins tapering more rapidly, surface slightly arched axially. Ventral face gently convex throughout and produced at the margin beyond the opposite face into a semielliptical extension; dorsal face convex but much less so than in H. r i c h a r d i, the

median portion the most elevated and bounded by two longitudinal grooves.   Apertural diameter to length of ventral face as 1 to 2.5; of dorsal face as 1 to 2.   The surface is marked only by concen-
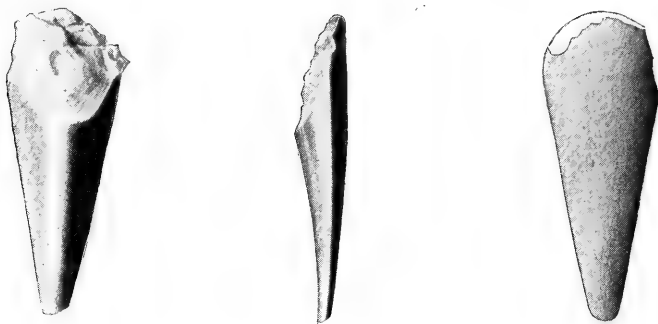
Hyolithus oxys

tric striae, arched upward on the dorsal face to correspond with the curvature of the margin; transverse on the ventral face. Average specimens measure 40 mm in length and 14 mm in apertural diameter.

Lower Devonic.   Grande Grève, P. Q.

Conularia penouili nov.

A large species distinctly grooved at the angles and ridged at the middle of each face.   The concentric markings are elevated
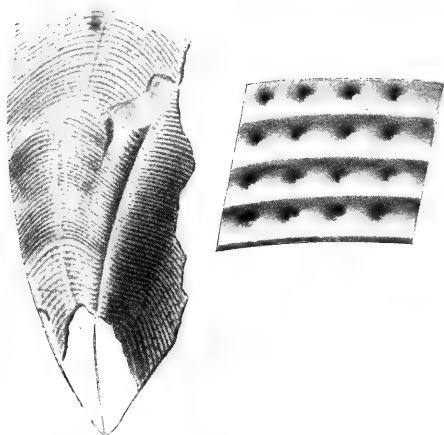
Conularia penouili

lines close together and curving broadly upward.   These are smooth on the edge, without ornament, but the interspaces have

sculpturing consisting of a series of low subcircular depressions in transverse rows separated by elevated surfaces which may take on the form of short convex pillars. This ornament is only about the middle of each face; toward the edges it fades away or is replaced by fine longitudinal puckers starting with the upper slope of a transverse ridge and passing down the slope and part way across the interspace.

Lower Devonic. Loose at Peninsula, P. Q.

Conularia desiderata Hall var. tuzoi nov.

This is a large shell having the surface characters similar to those of C. d e s i d e r a t a , that is, consisting of fine transverse

Conularia desiderata var. tuzoi

lines bending backward at the center and bearing extremely obscure tubercles visible only when the preservation is exceptional. Unlike C. d e s i d e r a t a the shells bear evidence of a faint median vertical but not interrupting line on each face.

Lower Devonic. Percé rock, P. Q.

GASTROPODS

Platyceras leboutillieri nov.

Shell small, erect, apex minute not exsert; minutely coiled for one and one third volution, then abruptly expanded with a spiral twist, the body whorl being erect and subcylindrical and the total

volutions less than two. There is no evidence of spirality in the body whorl beyond the first third of the shell. Section of body whorl
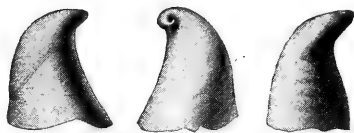
Platyceras leboutillieri

circular. Shell growth somewhat irregular in late stages but apparently without nodes.

Aperture but slightly undulated.

Hight from apex to stoma 18 mm, diameter of body whorl near aperture 14 mm.

Lower Devonic. Grande Grève and Percé rock, P. Q.

Platyceras gaspense nov.

A rather small species with small spiral of one and one half whorls very rapidly expanding so that at the end of the one and one half volutions the shell is of notable width; thence the whorl becoming free

Platyceras gaspense

and suberect, suggesting the outline of P. t h e t i s Hall of the Hamilton shales but with shorter body whorl and larger spire. The final whorl is compressed but appears to have been subelliptical in cross-section. Surface smooth with one or more longitudinal furrows.

Middle Devonic. Gaspé Basin, P. Q.

Platyceras paxillifer nov.

A small shell closely coiled for two and one half volutions or throughout its length, rapidly expanding and having the general aspect of a shallow Diaphorostoma or Strophostylus; the surface roughly corrugated concentrically, the upper shoulder of the shell bearing a single row of slender spines, beginning, in the best preserved specimens, at the end of the second whorl or the commencement of rapid expansion, and three in number at unequal intervals. This species represents one of the large group of spined Platycerata so frequent at this period in the development of the genus;

though none of this type has been described from the Helder-bergian fauna yet representatives are known to occur therein, and in the Oriskany of Glenerie we have the multispinous shell **P.**
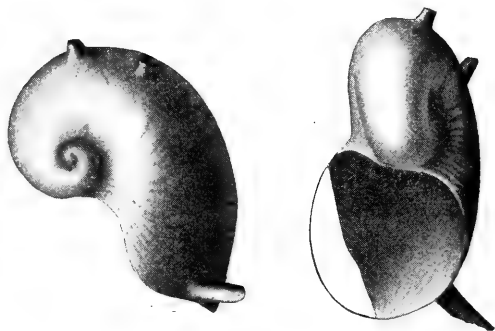
Platyceras paxillifer

n o d o s u m Conrad and P. s u b n o d o s u m Hall, which usually appear in the form of nodate casts.

In the Onondaga limestone fauna are P. d u m o s u m, e c h i - n a t u m, m u l t i s p i n o s u m, f o r n i c a t u m but among them all is none of the type expressed in P. p a x i l l i f e r .

Lower Devonic. Grande Grève, P. Q.

Platyceras guesnini nov.

Shell of medium size, suberect, subsymmetrically coiled; apex deeply coiled in horizontal plane, rapid expansion beginning at one and one half volutions, body whorl irregularly expanded, sub-circular in cross-section, direct and unattached for one half its

Platyceras guesnini

length. Surface without revolving furrows and ridges, and marked with subequidistant concentric undulating fringes gradually be-coming obsolete near the aperture; also traversed longitudinally by very fine revolving lines.

Lower Devonic. Percé rock, P. Q.

Platyceras lejeunii nov.

Shell of medium size with relatively small coil and rapidly ex-
panding suberect body whorl. Surface with subspiral or some-
what twisted longitudinal ridges crossing and festooning irregular
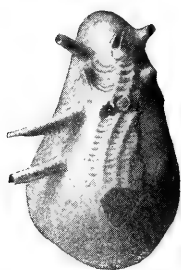
Platyceras lejeunii

concentric growth lines. The surface is covered with very long
and slender spines which are curved or arched backward. The
shell is more slender than other echinate species and the spines
relatively longer and more arched.

Lower Devonic. Grande Grève, P. Q.

Platyceras (Orthonychia) belli nov.

Shell erect, minutely arched and incurved at the apex, expand-
ing very gradually but equally for nearly one half its length and
thence more abruptly, the cross-section of the whorls being es-

Platyceras (Orthonychia) belli

sentially circular and the stomal margin undulated. Surface
crossed transversely by rugose concentric growth lines, their un-
dulations corresponding to low grooves and folds of the shell.
Length of a full-sized specimen 50 mm; stomal width 33 mm.

Lower Devonic. Grande Grève, P. Q.

Platyceras hebes nov.

Shell conical, slightly oblique, apex blunt or minute, surface expanding rapidly with a vertical slope on the posterior and a more broadly curved slope on the anterior side; lower part of the cone obscurely plicated, aperture nearly round.

This singular expression of Platyceras, noteworthy for its broad blunt apex, is quite unusual if not altogether new to American
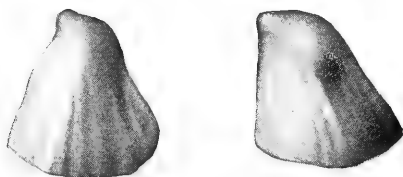
Platyceras hebes

faunas, but such a shell has been noticed by Oehlert in the Lower Devonic of Augen and figured in the *Bulletin de la Socièté Gèologique de France,* 1890, volume 17, plate 19, figure 4.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Platyceras kahlebergensis Beushausen

Capulus kahlebergensis Beushausen. Abhandl. zur geolog. Specialk. Preussen. 1884. pl. 1, fig. 14

There seems no doubt of identity in this case. The species is a Platyceras with a Diaphorostomalike spire from which the body

Platyceras kahlebergensis

whorl expands rapidly and carries a deep revolving sulcus on the lower side.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me., and in the Spiriferensandstein of the Hartz mountains at the Kahleberg.

Loxonema sp. cf. funatum A. Roemer

A shell of relatively rare occurrence with very faint sinuous ridges on the internal cast. It suggests the species referred

Loxonema cf. funatum

to from the Spiriferensandstein of the Hartz mountains. *Lower Devonic.* Edmunds Hill, Chapman Plantation, Me.

Holopea gaspesia nov.

Shell rather small. Spire short, whorls three to four, somewhat flattened beneath. Expansion rapid, sutures sharp but not deep though the sutural region may be flattened; nonumbilicate. Stoma subcircular. Surface with fine and close concentric lines which about the sutures are gathered into coarse raised radii which are lost before traversing one half the whorl. Some specimens
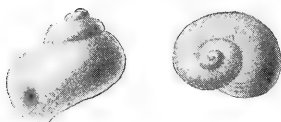
Holopea gaspesia

show a series of two or more revolving raised lines on the body at and below the periphery and two of these may be the boundaries of a slit band, though this feature can not be determined from the sandstone casts. This, however, does not appear to be a prevalent character of the species.

Dimensions. An average specimen has a hight of 10 mm and a basal diameter of 9 mm.

Middle Devonic. Gaspé Basin, P. Q.

Holopea wakehami nov.

Shell small, compact, with depressed spire, full ventricose body whorl and small obscure earlier whorls, suture impressed, hight

to width as four to three. Aperture broadly oval, entire; inner lip thickened and slightly excavated. Whorls four. Surface smooth or covered with very fine concentric lines. Average dimensions, hight 7 mm, width 5 mm. Distinguished from H. g a s p e s i a
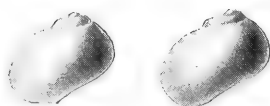
Holopea wakehami

by its rounder, more compact form, fuller whorls and more depressed spire. This species is in some of its expressions almost a miniature of the common M a c r o c h i l u s h a m i l t o n i a e Hall of the Hamilton shales of New York.

Middle Devonic. Gaspé Basin, P. Q.

Holopea enjalrani nov.

Small, rotund, Diaphorostoma-shaped shells with greatly expanded body whorl and low reduced spire. Whorls two and one half to three, greatly overlapping, sutures not impressed; aper·

Holopea enjalrani

ture entire, oval; base perforate. Surface of final whorl regularly convex and covered with fine regular concentric growth lines. Hight of typical example 10 mm, hight of body whorl 8 mm, width across base 12 mm.

Lower Devonic. Dalhousie, N. B.

Holopea enjalrani var. corrugata nov.

A shell of the same proportions as H. e n j a l r a n i carries a series of rather strong oblique corrugations on the body whorl parallel to the growth lines and somewhat swollen at the top near

the suture. It is an expression unusual at this early age though well known in Carbonic shells of similar type and as the de-
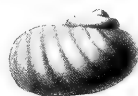
Holopea enjalrani var. corrugata

parture from H. e n j a l r a n i is alone in the clustering of the concentric growth striae into pilae, I should regard the shell a varietal expression of that species.

Lower Devonic. Dalhousie, N. B.

Holopea beushauseni nov.

M a c r o c h e i l u s ? sp. Beushausen. Abhandl. z. geol. Specialk. v. Preussen etc. 1884. pl. 1, fig. 7

Shell of considerable size, stoutly subconical with sutures slightly impressed; whorls four to five, depressed convex, overlapped for one fourth to one third of their width; surface smooth or with fine concentric lines; angle of spire 40 degrees; final whorl at its commencement having a diameter equal to the hight of the spire
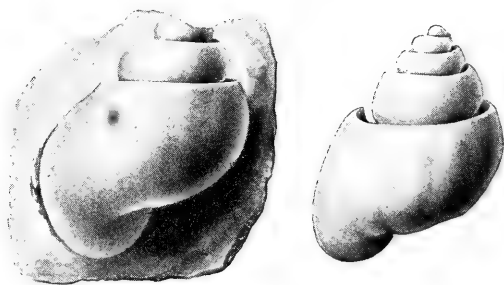
Holopea beushauseni

above; at the aperture much elongated, explanate or reflected in the lower part. The whorls sometimes show a slightly shouldered appearance and the final whorl may be subangular about its base. This shell occurs in great abundance in the form of distorted casts of the interior and is of the type of structure exhibited by such shells as C o n c h u l a s t e i n i n g e r i Koken [Neues Jahrb. für Mineral. Beilageband 6. 1889, pl. 13, fig. 2] and B u c i n u m a r c u l a t u m (Schlotheim) MVK [Fossils Older Dep. Rhen. Prov. 1842. pl. 32, fig. 1]. With the former it may be directly

compared. Both of these shells are from the Middle Devonic. Beushausen figures as Macrocheilus ? sp. an internal cast of like aspect and proportions from the Spiriferensandstein of the Oberharz (Bocksberg), identical indeed so far as identity can be indicated by internal casts. Specially noteworthy is the agreement in relative size of the final whorl and the explanate form of the apertural margin.

Lower Devonic. Presque Isle stream. A shell of somewhat similar character but apparently stouter with more convex whorls occurs at Edmunds Hill, Chapman Plantation, Me.

Coelidium strebloceras nov.

An extremely elongate and terete shell with not less than 20 volutions at full growth. The best preserved specimen has a length of 70 mm, and a width at the base of 11 mm. The later whorls display a sharp median angulation with a moderately broad and

Coelidium strebloceras

distinct slit band from which the slope to the suture is abrupt, more distinct and flattened above, more convex below.

This singularly delicate " Murchisonia " carries to an extreme the expression presented by some of the species described by Hall from the Guelph and by Lindstroem from the Gothlandian.

Lower Devonic. Dalhousie, N. B.

Coelidium tenue nov.

This is an elongate, turriculate and slender shell with sharply keeled whorls margined by a simple slit band to which the surface slopes in an almost direct plane without either convex or concave curvature, the surface of the whorls bearing reflected concentric lines. The species comes very close to Kayser's M u r c h i s o n i a l o s s e n i [Fauna des Hauptquartzites, p. 15, pl. 8, fig. 9] from the Spiriferensandstein of the Hartz and the Coblentzian of the Rhine. While approaching this form most closely it is also allied to the M. a n g u l a t a Phillips var. a. MVK [Fossils Older Deposits Rhenish Provinces, pl. 32, fig. 7] from the Stringocephalus
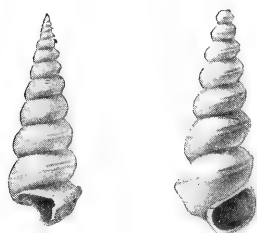
Coelidium tenue

limestone of the Rhine. Attention may also be directed to the shell identified by Verneuil from the Lower Devonic of Nishnij-Tagilsk in the Urals [Geol. de la Russie, 1845. v. 2, p. 339, pl. 22, fig. 7] under the name M. c i n g u l a t a Hisinger. Kayser remarks that this is not Hisinger's species, which is confined to the Swedish Upper Siluric. The forms described by Billings from the Gaspé limestone as M. h e b e and M. e g r e g i a are of the same type but are stouter shells with more convex volutions. ' The H o l o p e l l a o b s o l e t a of Sowerby figured by Murchison among the fossils of the Tilestones may be of similar type but it is known in literature only from internal casts which serve but a faulty purpose in the determination of such shells.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me. Abundant also at Dalhousie, N. B.

Eotomaria hitchcocki nov.

Shell with rather low, somewhat concave spiral of four to five whorls, the spire usually much depressed when in the shales. The surface of the whorls is regularly sloping, very slightly concave, giving an almost uninterrupted slope to the spire. Periphery

of body whorl sharply carinate or even extended into a keel or flange which seems to carry a slit band.   Aperture sharply angulated exteriorly, subcircular in outline, thickened and slightly excavate on the inner lip.   Base of shell broad and nearly flat for its full width.   Fine concentric growth lines are the only sculpture.   It is possible that this shell may be of similar character to the T r o c h u s ? h e l i c i t e s Sowerby from the Tilestones of Horeb Chapel [*see Siluria,* pl. 34, fig. 12] but comparison can be

Eotomaria hitchcocki

based only on the resemblance of the internal casts of the two shells for of the exterior of the latter we have as yet no definite knowledge.   It is instructive to observe that the Spiriferensandstein of the Oberharz (Bocksberg) carries an Eotomaria of similar style with extended peripheral flange [P l e u r o t o m a r i a k l e i n i Beushausen, *Beitr. zur Kenntn. d. Oberharz. Spiriferensandst.* 1884. pl. 1, fig. 10], though a shell of much larger type than that here described.

Lower Devonic.   Presque Isle stream and in the burnt lands 2 miles west, Chapman Plantation, Me.

Eotomaria ? rotula nov.

Shell small, spire greatly depressed below the level of the final whorl, so that the coiling has proceeded almost in a horizontal plane.
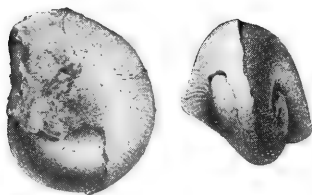
Eotomaria ? rotula

Whorls about two, gradually expanding and all in contact.   Outline of body whorl bilaterally subsymmetrical, expanding on the

lower side to the stoma. It bears a peripheral elevated or convex band which is bounded above by a sulcus, though not so well defined below. The upper shoulder of the whorl is subcarinate while the lower surface is broadly rounded and bears an oblique sulcus on the final third of the volution. Aperture sinuous, projecting above and reentrant in a broad curve below the position of the peripheral band. Surface crossed by fine concentric lines which curve forward on the upper surface of the whorl and make a retral turn on the periphery whence they again curve forward in a broad sweep, on the lower surface being interrupted by the interior sulcus.

Lower Devonic. Grande Grève, P. Q.

Trochonema lescarboti nov.

Shell moderately large, trochiform. Whorls broadly sulcate above, gently convex peripherally and regularly convex below; three to four in number. Sutures impressed and bounded by an elevated ridge or carina within which the surface is depressed in a broad and shallow sulcus bounded outwardly by a sharp keel

Trochonema lescarboti

which lies at the shoulder of the whorl and from which the whorl surface is abruptly depressed. No peripheral band is known though the internal cast bears a peripheral depression. Lower surface not known except from the cast, apparently regularly convex. Surface marked by regular concentric lines without revolving striae.

Lower Devonic. Percé rock, P. Q.

Phragmostoma diopetes nov.

A small bellerophontid with well developed slit band and apparently smooth surface save for regular concentric growth lines. The shell expands rapidly to an explanate mouth which involves

the spire and forms a broad flat plate on the posterior region with the callus about the spire extending into the aperture, making a
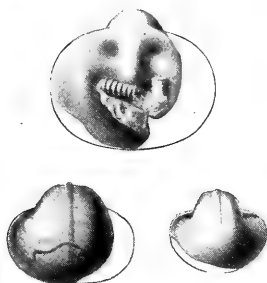
Phragmostoma diopetes

structure altogether similar to that of P. n a t a t o r (Portage group), the type of the genus.

Lower Devonic. Matagamon lake, Me.

Tropidodiscus obex nov.

This is a species of unusual interest in that it represents the only member of the genus known, save the type T. c u r v i l i n e a t u s (Conrad) from the Onondaga limestone of New York. The Maine shell is smaller than that, very sharply keeled, narrowly umbilicated,
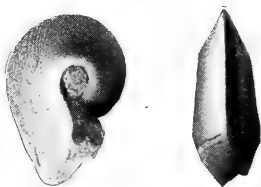
Tropidodiscus obex

with the outward slope of the whorls direct and without evidence of revolving sulci, the inner slope being vertical. The surface is crossed by fine concentric growth lines bending sharply back to the keel.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Euphemus ? quebecensis nov.

To this well known Carbonic genus I refer with doubt flat or discoid, involute, horizontally coiled shells having a goniatitic aspect, the final whorl deeply overlapping the preceding and closing

the umbilicus.   The whorls are narrow but deep, abruptly curved
on the periphery; the stoma expanded but not explanate.   The sur-
face is marked by regular simple and continuous elevated revolv-
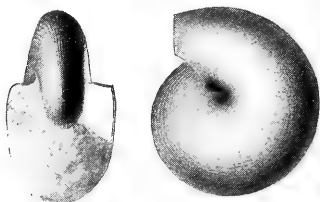
Euphemus ?   quebecensis

ing lines which become crowded toward the aperture.   There is
no evidence of a slit band.   The shell has a diameter of 10 mm.

This species represents a very unusual type of structure for a
Devonic bellerophontid but is provisionally placed in this associa-
tion.

Middle Devonic.   Gaspé Basin, Gaspé.

Bellerophon (Plectonotus?) gaspensis nov.

Shell rotuloid, rapidly expanding; expanded but not explanate
at the aperture.   Outer surface trilobed by two revolving lateral
furrows which start early and become wider and deeper with age.
These do not divide the surface equally but the lateral divisions
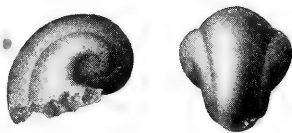
Bellerophon   (Plectonotús)   gaspensis

are considerably narrower than the median division which is broad,
prominent and elevated but flattened on top and may have had a
peripheral seam.   The specimen measures 12 mm in diameter and
has about the same apertural width.

Lower Devonic.   Grande Grève, P. Q.

Probolaeum ? canadense nov.

We are disposed to regard as a representative of the Polyplaco-
phora or chitons an elongated semicone-shaped plate sinuate on its
front margin, with a posterior terminal beak and broadly infolded
posterior margin.   The characters of this plate are shown in the

figure drawn from a sculpture cast, displaying the sharp concentric growth lines which are crowded together on the infolded part of the test. The length is 28 mm and the anterior width 19 mm.

In the Devonic of the Appalachian gulf no chitons have been

Probolaeum ? canadense

found, though these bodies are known from several horizons in the transatlantic Devonic. There is noteworthy similarity in the form and aspect of P. canadense to Chiton sagittalis Sandberger (Stringocephalus limestone).[1]

Lower Devonic. St. Alban beds, Cape Rosier Cove, P. Q.

PELECYPODS

Aviculopecten alcis nov.

Shell slightly oblique with anterior beak and short anterior wing. Hinge and posterior wing not extending as far back as the shell
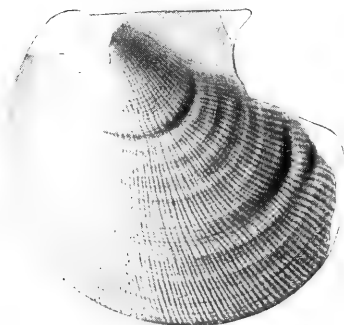
Aviculopecten alcis

outline. Curvature of the margin gently convex in front and anterolaterally, narrowed and slightly produced behind. Body of the shell gently convex; length and hight equal. Surface covered by fine radial riblets of unequal size, close together, generally with some tendency to fasciculation behind, fine and fainter and closely crowded in front. These are all crossed by very fine concentric

[1] Verstein. rhein. Schichtensys. p. 239, pl. 26, fig. 23.

lines and coarse concentric wrinkles which are quite irregularly spaced. This description is based wholly on a left valve to which it has seemed unsafe to refer any associated right valves. Though there are ribbed Aviculopectens in all the formations here brought under consideration I know none which agrees with or approaches this.

Lower Devonic. Moosehead lake, 7 miles north of Kineo, Me.

Aviculopecten flammiger nov.

This is a shell of somewhat variable exterior which approaches in outline the P t e r i n o p e c t e n p r o t e u s Clarke of the Be-craft Mountain Oriskany [*see* N. Y. State Mus. Mem. 3, p. 32, pl. 4, fig. 7], but it is unlike that in exterior. The round sub-circular shell is strongly radiated, the primary radii being some-times coarse with broad fascicles of intermediate striae, sometimes

Aviculopecten flammiger

finer and less distinctly fasciculate. In the number of these pri-mary ribs there is the greatest variation. All are crossed by sharply elevated concentric striae. The anterior wing is deeply sulcate and sinuous, the posterior relatively large and with concentric striae only. Only left valves of this species have been observed and they are readily recognized in spite of their variable ornament.

Lower Devonic. Askwith siding, Misery stream and Moose river, Me.

Aviculopecten jumeaui nov.

Shell of considerable size, suberect, explanate below, with sub-orbicular outline tending to obliquity posteriorly. Beak anterior, anterior wing short, posterior broad flat or subconcave, the point not extending beyond the posterior curve of the shell; sharply incurved on the lateral margin. Surface with fasciculate bands somewhat after the type of ornament in A c t i n o p t e r i a t e x -t i l i s ; coarse distant ribs with intermediate smooth spaces divided

by a simple low rib, these interspaces being subdivided near the margin. Concentric sublamellose lines at distant intervals. On

Aviculopecten jumeaui

the wing radial lines are obscure but concentric lines sharp and crowded.

Dimensions. The typical specimen has a length of 47 mm; hight of 42 mm.

Lower Devonic. Percé rock, P. Q.

Aviculopecten ? incrassatus nov.

Shell large, outline obliquely subelliptical. Posterior wing short. Surface with coarse and heavy radial ribs of unequal size separ-

Aviculopecten ? incrassatus

ated by relatively narrow rounded grooves. Inequality in the size of the ribs is noticeable in the umbonal region and new ribs are
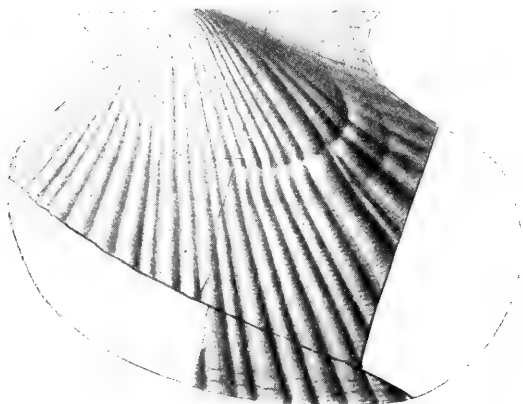
added by division of the large ones. All are crossed by a concentric ornament of fine compressed lines with occasional deep concentric growth furrows. This type of ornamentation is an extreme condition of that sometimes expressed by P t e r i n o p e c - t e n   p r o t e u s. The original specimen has a hight of 50 mm and a probable length of 70 mm.

Lower Devonic. Grande Grève, P. Q.

Actinopteria (Pterinea) fronsacia nov.

This is a species having somewhat the aspect of the common and well known A. b o y d i of the Hamilton fauna of New York, but more erect and with a larger auricle. Its surface is marked by quite regularly alternating radii and these are crossed by imbricating concentric lines which are closely crowded together
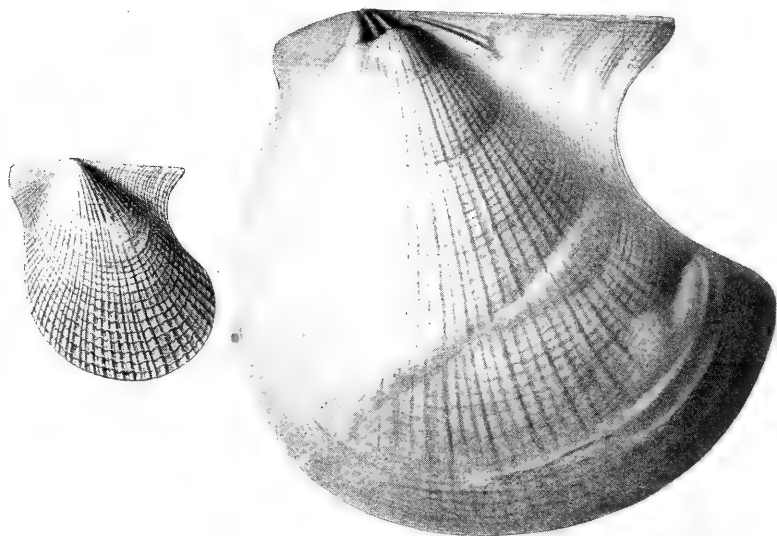
Actinopteria (Pterinea) fronsacia

and crenulated fore and aft. In A. b o y d i the radial riblets are of more uniform size and as usually preserved in the shales show only inconspicuous evidence of the lamellose concentric lines here present. More closely allied in ornament and in form is the A. e s c h w e g i i Clarke[1], from the Lower Devonic Maecurú sandstone of the Amazonas.

Middle Devonic. Gaspé Basin, P. Q.

[1]Archivos do Mus. Nac. Rio de Janeiro. 1899. 10:45, pl. 5, fig. 9.

Pterinopecten denysi nov.

Shell moderately large, subcircular, known only from its left valve which in the single specimen before us is somewhat incomplete about the hinge but has a very characteristic sculpture. This consists primarily of a few strong radial ribs of unequal size, which rapidly spread apart leaving broad interspaces which do not, in any noticeable degree on the body of the shell, become occupied by other ribs, except small and simple ones of a secondary series.
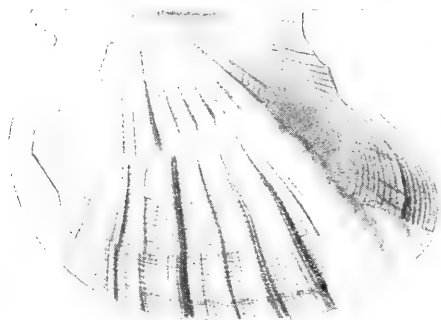
Pterinopecten denysi

The primary ribs themselves widen, become broad and flat and split up into lesser ones, though all derived from the division of any rib may remain together in a fascicle. On the anterior part of the shell the diffusion of the riblets is less defined and regular. All these are crossed by very fine reticulating concentric striae. This is a style of irregular sculpture which with more specimens would probably prove to be quite inconstant and is in a measure reproduced in the very variable species from the Oriskany of New York, which we have designated as P. proteus. A similar aspect is presented by the P. wulfi Frech from the lower Coblentzian of the Eifel.[1]

Lower Devonic. Dalhousie, N. B.

Pterinopecten aroostooki nov.

Shells subcircular or somewhat transverse with outline slightly extended posteriorly; beak at the anterior third of the hinge, posterior hinge straight, reaching to the extreme limit of the outline, posterior wing very slightly extended; anterior hinge straight, anterior wing moderately large but undulated, an oblique ridge traversing it from the beak just beneath the hinge leaving the portion behind it depressed and flat. Below this ridge the ear is de-

[1] Devon. Aviculiden Deutschlands, p. 25, pl. 2, fig. 7.

pressed or broadly sulcate. Umbo convex, narrow; pallial region
sloping evenly downward and depressed. The surface sculpture
consists of well defined ribs, which are broad and sparse over the
median region where they usually carry one very small rib between
each two of the large ones. On the anterior slope and wing these
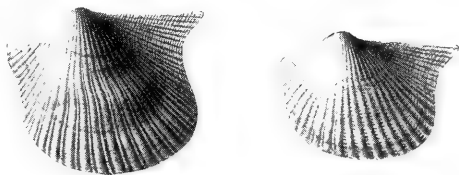
Pterinopecten aroostooki

ribs are smaller and also on the posterior slope and wing. Cancel-
lating lamellae cross the posterior wing and are visible in the sulci
of all the posterior surface of the valve. The left valves only are
known.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Limoptera rosieri nov.

This large and rather fine species has a flabellate outline with
umbones almost at the anterior end of the hinge. The hinge line

Limoptera rosieri

is very long and straight terminating posteriorly on the extreme
point of a very broad wing. The incurvature from this wing

toward the body of the shell is but slight, but the area is set off by a low, broad depression on the surface and a distinct change of curvature in the surface lines. The body of this shell is broad and transverse, the curvature being regularly suboval, while the anterior course of the margin is much more direct, curving outwardly below and slightly incurved above. The anterior wing is very small, separated from the umbones by a deep sulcus. The ligament area is very broad and is longitudinally lined. The ornament lines of the surface consist of distinct concentric lamellae, becoming more closely arranged near the margins. Their interspaces are crossed and the lamellae themselves notched or crenulated by subequally distant elevated radial lines. The reticulated and fimbriated effect is specially shown on the posterior wing. Our specimens show the following dimensions: Length on hinge, 100 mm, hight and length of body, 90 mm.

Lower Devonic. St. Alban beds, Cape Rosier Cove, P. Q.

Pterinea mainensis nov.

Shell often of large size, oblique, hinge considerably shorter than the full length of the valve. Anterior wing well developed, but slightly sloping at the hinge and set off from the shell body
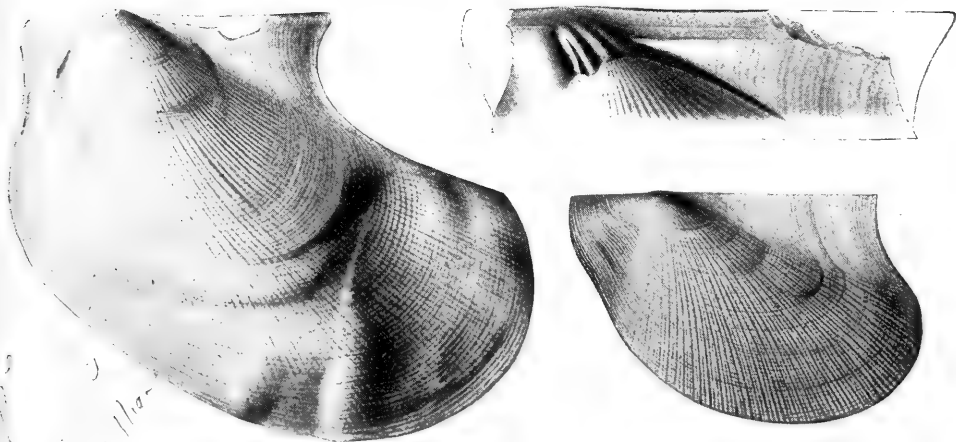
Pterinea mainensis

by a low broad sulcus. Posterior wing relatively short not reaching the posterolateral limit of the valve and sometimes not more than one half or two thirds this distance. Body of the valves depressed not sharply set off from the wings; anterior outline at first direct, then inclining more or less rapidly backward and often

extended at the posterolateral margin from which the retreat
toward the posterior wing is abruptly oblique. The surface of
the left valve is covered by fine radii, equal on the anterior slope
but unequal on the posterior and showing a tendency to fascicula-
tion. These are minutely cancellated by concentric lines which on
the anterior slope and wing and on the posterior slope become
prominent to the exclusion of the radii. The right valve is shallow,
evenly depressed, with the radii along the crescence line stronger
and more distant and the cancellating lines subdued.

The hinge is distinctly pterineoid, showing a doubly divided um-
bonal tooth, strong oblique posterior ridge and broad, striated liga-
ment surface.

This shell, extraordinarily abundant at some localities, is readily
recognized by its extremely fine radial surface markings accom-
panying unusual size.

Lower Devonic. Telos lake dam and Moosehead lake, 7 miles
north of Kineo, Me.

Pterinea moneris nov.

Somewhat oblique valves with hinge line less than the greatest
length, anterior beaks, and moderately developed posterior wing.
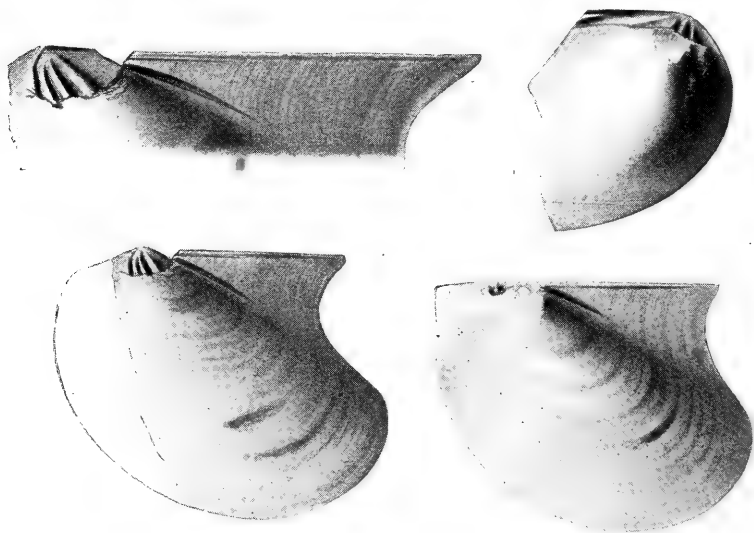
Pterinea moneris

The surface is depressed and entirely devoid of radial markings on
either body or wing, thus only concentric lines or rough wrinkles
are present.

The umbonal teeth are strongly developed in the left valve as a set of three oblique ridges, behind them being a strong oblique ridge. What may prove to be the right valve of the species has a more convex surface, strong anterior muscle scar and teeth to correspond with the sockets of the other valve.

This species is like but much more oblique than the P. foll-manni Frech and P. laevis Goldfuss of the Coblentzian.

Lower Devonic. Webster lake, north side, ¼ mile east of Telos canal and Matagamon lake, on east side 1 mile above dam, Me.

Pterinea chapmani nov.

A large left valve has the beak almost terminal, a long straight hinge, lateral teeth not visible but umbonal teeth sharply defined; posterior wing narrow and not extended, anterior wing very small; anterior slope abrupt, almost vertical; umbo narrow elevated, the
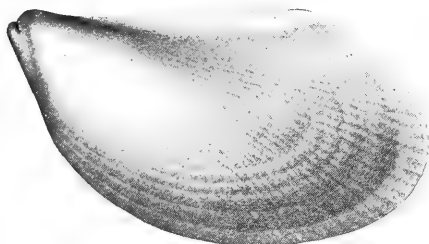
Pterinea chapmani

general surface of the valve broadly convex; outline oblique. The surface carries faint radial riblets, which are obsolete on the anterior slope.

The species differs from any of its associates in its obliquity, abrupt anterior slope, abbreviated anterior wing and short posterior extension.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Pterinea edmundi nov.

The distinguishing marks of this species are found in its ornament and variable outline. In aspect it approaches very closely the P. radialis from Presque Isle stream but its left valve is sometimes more oblique, sometimes more erect, its umbonal convexity less marked. Its sculpture consists of coarse flattened ribs which are more or less irregularly interspersed with ribs of smaller size; on the anterior slope these gradually disappear leaving the

anterior ear smooth, but on the posterior slope they are continued to the hinge. The posterior wing is cancellated and the cardinal line more strongly striate. The left valve which is less convex than the other has the radial riblets developed only on the median area, both anterior and posterior wings being smooth save on the
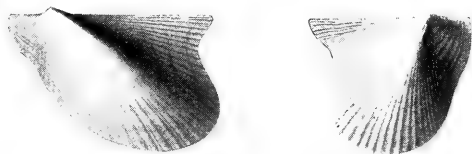
Pterinea edmundi

posterior hinge where is a cancellated group of three or four strong radii. The variations in the outline of this species reach an extreme in the variety s u b r e c t a , which retains the same style of ornament as the foregoing and relative proportions and development of the parts, but is quite erect. This appears to be a persistent feature which we find exemplified in several examples.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Pterinea cf. fasciculata Goldfuss

P t e r i n e a f a s c i c u l a t a Goldfuss. Petrefacta Germaniae, 2:137, pl. 129, fig. 5
P t e r i n e a f a s c i c u l a t a Frech. Devon. Aviculiden Deutschlands 1891. p. 84, pl. 8, fig. 1; pl. 9, fig. 1–3

This species is radially and coarsely ribbed, quite convex and oblique along the crescence line, the anterior wing strongly
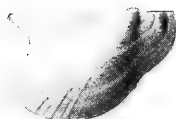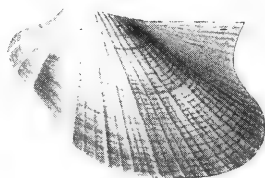
Pterinea cf. fasciculata Goldfuss

developed on the abrupt anterior slope and the hinge teeth both beneath the beak and behind it very pronounced. It is very

like the species cited in all respects so far as the former is known. It is, however, possible that some of the coarsely ribbed internal casts may belong to the more finely marked form to which we refer in the following.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Pterinea fasciculata Goldfuss
var. **occidentalis** nov.

See P t e r i n e a f a s c i c u l a t a Goldfuss. Petrefacta Germaniae, 2: 137, pl. 129, fig. 5, and Frech. Devon. Aviculiden Deutschlands. 1891. p. 84, pl. 8, fig. 1; pl. 9, fig. 1–3.

This extremely common shell is essentially a miniature of P. f a s c i c u l a t a Goldfuss. Though reduced in all its proportions and in the strength of its ornament yet it expresses excellently the characters of the German species. The valves are both convex, the left notably and the right but slightly. The left valve has the body well elevated above the posterior wing. This wing is sometimes more incurved at the margin and more extended at the point than in the figured German specimens but these features are variable in the Dalhousie shells. The body of the shell or direction of the crescence line is commonly more oblique than in European specimens but this is an expression due in some measure to mode of preservation, for examples occur here quite as erect as those referred to. The breadth of the byssal groove and emargination on the valve are also notable; together with the relative development of the anterior ear they are in full agreement with P. f a s c i c u l a t a. The surface of this valve is marked by coarsely fasciculated radial striae. The major ribs do not exceed five or six but these are widely separated on the body of the shell, the interspaces occupied by radii of lower order.

On the posterior slope the striae are of uniform size and are visible on the wing. On the anterior wing there are two or three coarse riblets but the byssal sinus is deep and without radii. Crossing these elevated radial lines are fine crowded and elevated concentric lines giving all the surface except the byssal sinus a reticulate ornament.

The right valve is much less convex than the left, the anterior wing relatively large, the byssal sinus deep, the body of the shell

depressed.   The surface bears a few simple filiform radial lines
along the body of the shell and others are visible on the posterior
wing at the hinge.   No concentric lines are evident.

Lower Devonic.   Dalhousie, N. B.

Pterinea intercostata nov.

Shell suberect or oblique with small auricle and well defined,
broad but not extended posterior ear.   Hinge straight, about two
thirds the greatest diameter of the shell.   Beaks anterior, subter-
minal.   Left valve with coarse and strong radial ribs separated by
broad flat interspaces.   Of these one can count about 12 on the
body of the shell.   The primary interspaces are usually divided by
a much finer median riblet but further subdivision is very unusual.
On the broad posterior wing radial ribs are sparse and indistinct
though usually traces of them may be seen.   Here the fine concen-
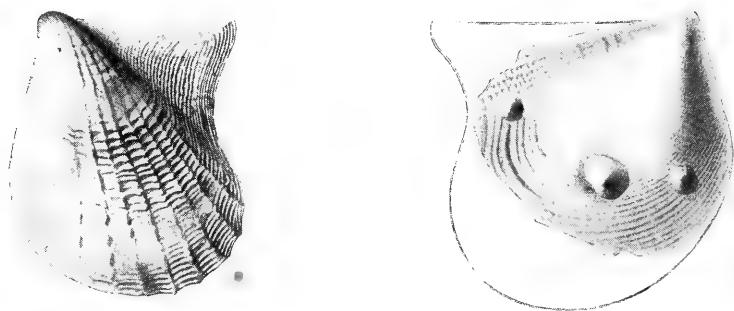
Pterinea intercostata

tric lines predominate, giving the surface a smoothness in contrast
to the rest of the valve.   The concentric lines are also visible on
the rest of the surface.   As usually preserved they make faint
interruptions of the radial ribs but when normal are lamellose and
strongly defined.   The right valve is practically devoid of radial
sculpture, the surface being crossed by sharply defined concentric
lines, only the posterior wing showing a few riblets on the cast.
The contrast in the markings of the two valves is extreme but is
conclusively demonstrated by several specimens with both valves
retained.

This species may be compared in respect to ornament with several
coarsely ribbed shells, e.g. P. c o s t a t a Goldfs., A v i c u l a

rigomagensis Frech, from the Coblentzian, A. reticulata
Sowerby, from the Aymestry limestone, but such comparisons are
resemblances only in one or another feature. No closely allied
form is now recognized.

Lower Devonic. Dalhousie, N. B.

Pterinea radialis nov.

This is one of a group with an Actinopterialike exterior, but it
has the highly developed anterior muscle scar, the umbonal and
the lateral teeth of Pterinea. No attempts therefore at correlation
with species which have been determined as Actinopteria and
Avicula are here called for. The shells have the size and propor-
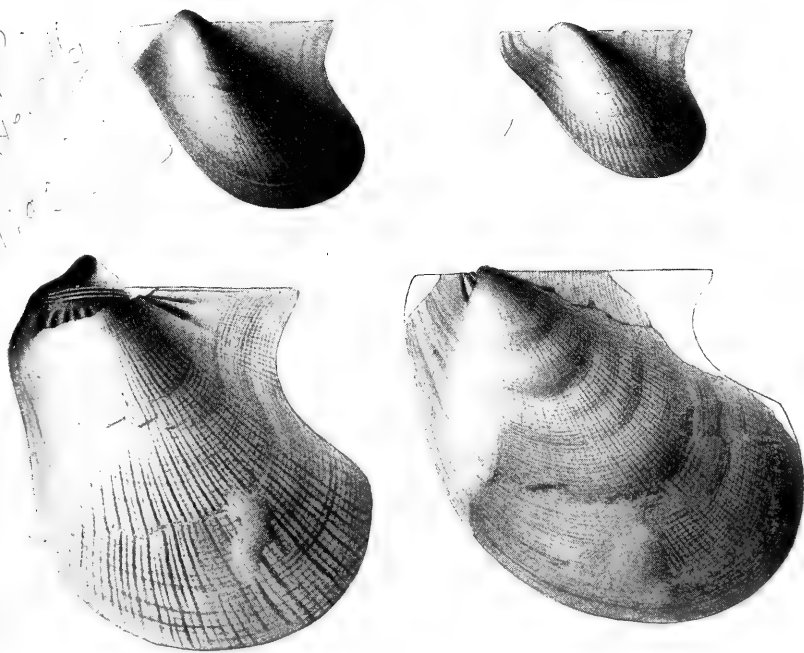
Pterinea radialis

Upper figures the usual form at Chapman Plantation; lower figures exemplify the larger size
attained at Matagamon lake.

tions of the foregoing (P. cf. fasciculata) and the following
species. The hinge line is but slightly extended posteriorly, the
anterior wing well marked, convex and sulcated; the crescence
line oblique and the valve highly convex in the umbonal region,
with abrupt anterior and more gradual posterior slope. The sur-

face sculpture consists of closely crowded subequal rounded riblets, alternation of size being noticeable near the margins.

Lower Devonic. Presque Isle stream, Chapman Plantation, Matagamon lake and elsewhere, Me.

Pterinea ? mytiloides nov.

A Leptodesmalike shell, extremely oblique and elongate with a subacute anterior extremity, anterior beak, short hinge, oblique broadly rounded umbonal ridge terminating in a broad blunt posterior extremity. The lower margin of the valve makes at the

Pterinea ? mytiloides

anterior extremity an angle of about 40 degrees with the hinge, is slightly incurved by the broad and obscure cincture in front of the umbonal ridge.

Dimensions. The best preserved example has a length from anterior end to postlateral curve of 25 mm; hight from the beak 7 mm; greatest hight 12 mm.

This species is provisionally referred to Pterinea and it is more than doubtful if it has any immediate relations with Leptodesma Hall in the sense in which that name was employed by its author. Its age and surroundings indicate that it has direct pterineoid affinities. The shell is rare but its form leads to its ready recognition.

Lower Devonic. Dalhousie, N. B.

Pterinea brisa nov.

An elongate shell, quite erect, the axis of growth being essentially at right angles to the hinge. The body is produced and moderately expanded; the wings distinctly developed but not large, the posterior being narrow, the anterior short and the byssal sinus well defined. The length of the hinge in the specimen before us is 32 mm, the vertical hight 40 mm. The beak is at the anterior third of the hinge. The surface is marked by radial elevated lines with broad, flat interspaces, broken by intercalated lines of minor series. In the

umbonal region the lines are close together but they spread out-
ward and the primary interspaces become broad.   The body of the

Pterinea brisa

valve shows few concentric lines but these are strong on the wings
and those on the posterior wing are cancellated by the radii near
the hinge.

Lower Devonic.   Edmunds Hill, Chapman Plantation, Me.

Pterinea brisa var. vexillum nov.

A right valve is suberect with a semicircular lower margin, deep
byssal sinus, short but well defined anterior wing and broad pos-
terior wing extended to an acute posterior angle.   Its surface is
flat or slightly concave in the pallial region.   The sculpture con-
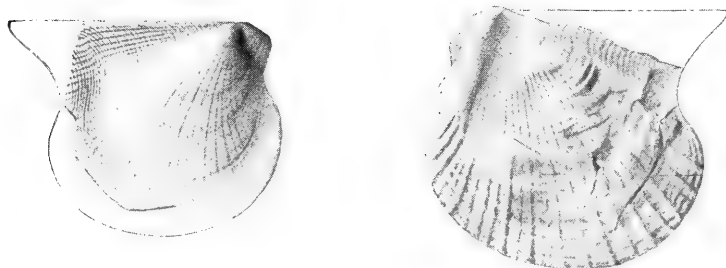
Pterinea brisa var. vexillum

sists of fine radial riblets of subequal size moderately distant and
numerous over the body of the valve, very obscure on the posterior
wing, which is entirely covered by concentric crowded lamellose
lines; the latter are extremely faint over the rest of the shell.   A
less complete specimen in which the left valve is impressed upon
the right shows that the surface of the latter was crossed by very
strong radial and very distant ribs, the broad flat interspaces some-

times carrying intercalating ribs of lower order. These were crossed by concentric lines, presumably lamellae. The aspect of the surface is thus not unlike that of P. i n t e r c o s t a t a but the outline is very different and the right valve is distinctly ribbed. The species P. b r i s a from Chapman Plantation, the description of which is based on a right valve, is a very close approach to this in respect to outline and surface characters, though a more elongate, erect shell. To express this intimate relation the present form is regarded as a variety of the latter.

Lower Devonic. Dalhousie, N. B.

Pterinea (Pteronitella?) incurvata nov.

Valves elongate on the hinge, the greatest length of the hinge being almost twice the hight of the shell. Anterior wing well defined on both valves, byssal sinus not deep but broad and not marked by a notch on the right valve. Beaks one third the length of the hinge from the anterior extremity. General outline very oblique. Left valve highly convex and incurved over the body, sloping abruptly to the posterior wing, more gradually to the
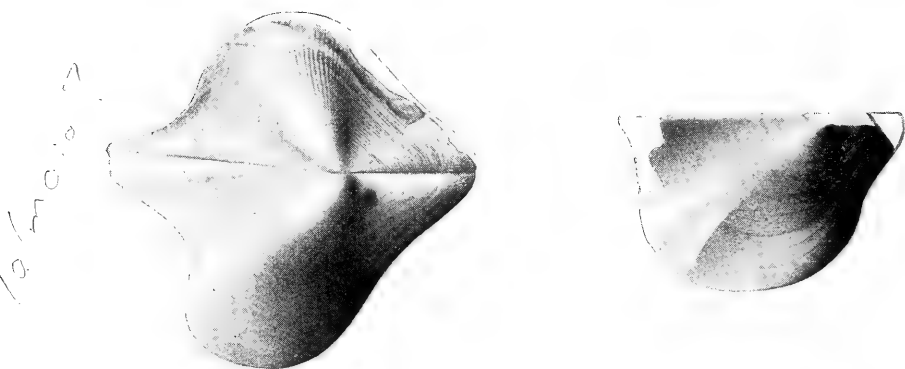
Pterinea (Pteronitella?) incurvata

broad byssal sinus in front. From the prominent umbo the crescence line swings in a curve backward and forms a strong projection on the lower margin. The posterior wing is extended well beyond the posterior margin of the body and bounded by a concave curve which terminates in an acute point. Its surface is depressed in a direction conforming with the curve of the body. The surface of this valve is covered with regular concentric growth lines which are essentially unmodified on the anterior and posterior wings but the body of the valve bears radial striae which have

somewhat the aspect of unequal and flat riblets produced by series of incised lines. These multiply and broaden unequally presenting much the same aspect as those in P. e d m u n d i of the Chapman Plantation.

The right valve is depressed; on the posterior wing deeply concave, convex but not elevated along the crescence line, thence sloping to the lower margin with an incurved surface, the postlateral edge of the valve being upturned. The byssal notch and sinus are indicated by a marginal incurvature and depression. One specimen shows the striated ligament area, a small anterior adductor and slender anterior tooth. Surface of this valve entirely smooth or with concentric lines only.

This shell is characterized by its extreme convexity and incurvature.

Lower Devonic. Dalhousie, N. B.

Pteronitella hirundo nov.

Shell much elongate on the hinge, terminating posteriorly in a slender, acute point, anteriorly blunt, the auricle atrophied and the anterior slope of the valves abrupt. Beak subterminal, elevated, umbonal ridge subparallel with the anterior margin. From this ridge the surface of the left valve slopes very gradually
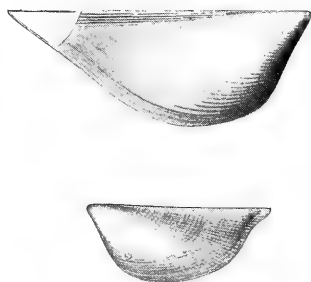
Pteronitella hirundo

downward and back; right valve flat except at the beak. Surface of left valve bearing sharp and numerous radial lines, crowded and with a tendency to fasciculation over the anterior and lower parts but equidistant posteriorly. The hinge and ligament areas are bounded and crossed by a few very strong striae, the cardinal edge of the valve being thickened. All these lines are crossed by concentric striae, short and elevated everywhere except on the posterior cardinal surface. On the right valve the radial lines are obsolete

except on the posterior wing near the hinge, only the concentric lines standing out sharply and equidistant. The inner surface of both valves is quite smooth. This is a striking species well defined by its outline and surface characters. Its thin shell has left insufficient evidence of its dentition but I have referred it to Pteronitella largely because of its general aspect.

Lower Devonic. Dalhousie, N. B.

Pteronitella passer nov.

This differs from the preceding in presenting a less extended and rather blunt posterior extremity, a more conspicuous anterior ear and a relatively greater breadth. The outline is still elongate with a gentle surface slope on all sides except the front where it
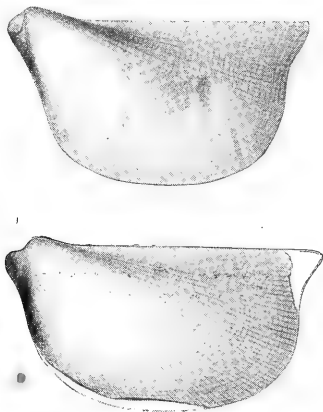
Pteronitella passer

is quite abrupt. The surface is fully reticulated by radial and concentric lines, the former being as before stronger along the posterior wing.

In my judgment this will be readily distinguished by its outline as exhibited in two left valves here figured, though it is undeniably similar to P. h i r u n d o in many of its characters.

Lower Devonic. Dalhousie, N. B.

Pteronitella peninsulae nov.

Very sharp internal casts of right valves show the characteristic structure of this genus as defined by Billings, clearly demonstrating the departure from the type of Pteronites in the presence of a series of Cyrtodontalike teeth beneath the beak together with the

long posterior ridgelike tooth. These valves are very oblique, the straight hinge making the greatest diameter of the shell; the anterior wing is insignificant and the posterior not extended. From
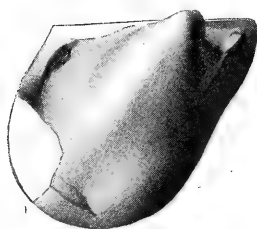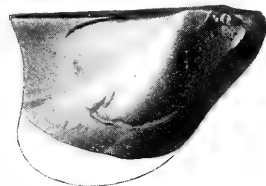
Pteronitella peninsulae

anterior and posterior cardinal angles the lateral margins depart at almost 90 degrees. The beak is very near the anterior extremity and the shell is quite convex along the oblique and somewhat curved crescence line, from which the anterior slope is abrupt and the posterior abrupt and slightly concave at first becoming flat at the hinge. The anterior scar is small and deep, the posterior large and faint. Beneath the beak are three or four teeth diverging from the edge of the ligament area.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Myalina pterinaeoides nov.

One of the commoner species at Presque Isle stream is a Myalina with a striking resemblance throughout, save in the character of the hinge, to certain Pterineas with curtailed posterior wing, and specially similar to Pt. f o l l m a n n i Frech.[1]

The frequent internal casts show the species to be devoid of the hinge teeth of Pterinea and present only the moderately broad ligamental striations of Myalina and the abbreviated earless and abrupt front margin. This latter feature is rather feebly developed but when the shell is retained the anterior incurvature

[1]Frech. *op. cit.* pl. 10, fig. 5: Drevermann. Fauna d. Untercoblenzsch, p. 82, pl. 10, fig. 1, 2.

with margins truncated and meeting at right angles is evident.
In other respects we may note the following characters: The shell
is relatively suberect without posterior hinge, obliquely elongate,
suboval with greatest width across the pallial region, the hinge
line being short, not more than one half as long as the length
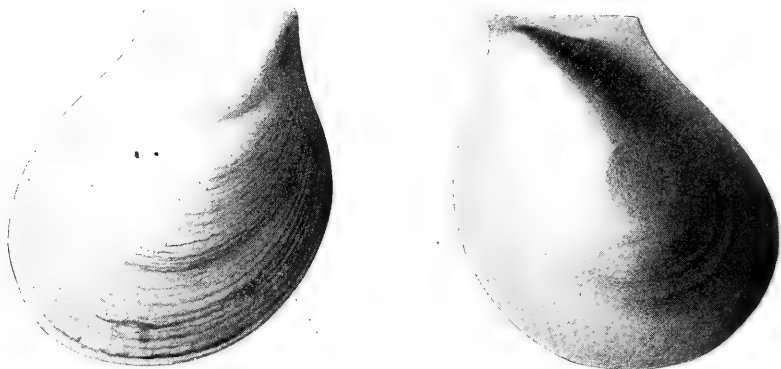
Myalina pterinaeoides

of the shell. The valves are shallow and thick; posterior muscle
scar well defined, situated at one half the length of the shell;
pallial line short, barely reaching beyond the middle; anterior scar
absent.

The surface of the shell is coarsely rugose in concentric growth
lines and is without other ornament. Of such a species as this
we know nothing among the faunas of the Appalachian early
Devonic.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Cyrtodonta beyrichi Beushausen

Cyrtodonta beyrichi Beushausen. Beitr. zur. Kenntn. d. Ob-
    erharzen Spiriferensandsteins. 1884. p. 67, pl. 3, fig. 2, 3.

I am disposed to refer to this species without much reservation
certain subcircular shells of Paracyclaslike outline with quite con-
vex surface, slightly depressed behind and faintly sinuous in front.
In these the hinge has the structure of Cyrtodonta strongly de-
veloped—the curved double anterior teeth and the long lateral
or posterior grooves and ridges. Beushausen's figures were made
from internal casts but they display the general outline and size
of those before us.

The genus Cyrtodonta has not been observed in the Devonic
rocks of the Appalachian province and its occurrence in the eastern

region is of decided interest. While these Devonic species seem to agree in hinge structure with those which have been referred to the genus from the Lower Siluric yet it is possible that differences may be found and Beushausen's recognition of the
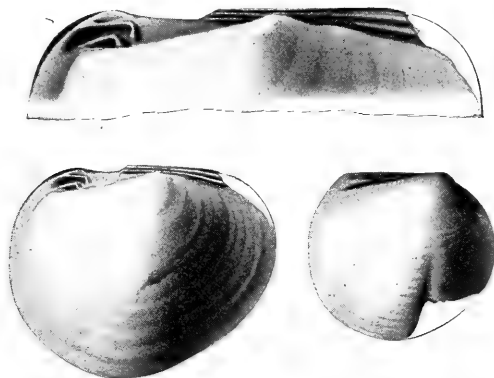
Cyrtodonta beyrichi

validity of Cyrtodonta which has commonly been regarded a synonym of Conrad's term Cypricardites, has been indorsed by Ulrich [Paleontology of Minnesota, 1897. v. 3, p. 534] who has elaborately illustrated the Siluric species. C y r t o d o n t a b e y - r i c h i in Germany occurs in the Spiriferensandstein of the Hartz mountains at the Kahleberg.

Lower Devonic. Moosehead lake, 7 miles north of Kineo, Me.

Cyrtodonta muscula nov.

Much more elongate than the preceding, retaining the pterineoid
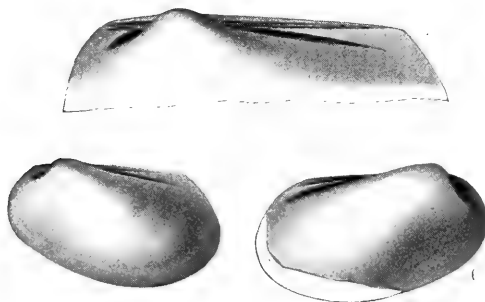
Cyrtodonta muscula

form, narrow in front, widening backward and with a broad anterior sinus. Hinge as in the other species.

Lower Devonic. Moosehead lake, 7 miles north of Kineo, Me.

Megambonia denysia nov.

Shell very small, suborbicular in outline and rotund in contour. Auricle not prominent, byssal groove broad shallow and indistinct, but visible nearly to the beak. Surface very finely radiate on the body of the shell but with fewer radii on the auricle. The
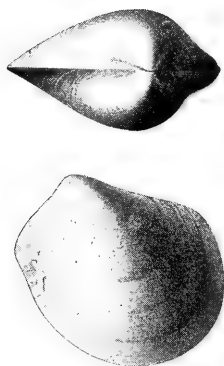
Megambonia denysia

orbicular outline, regular convexity and feeble byssal groove seem to indicate this as distinct from M. c r e n i s t r i a t a Clarke, though not varying materially in surface characters. Further knowledge of the shell may determine a closer relationship in the two.

Lower Devonic. Percé rock, P. Q.

Mytilarca dalhousie nov.

Cf. M. o v a t a Hall. Palaeontology of New York, 3: 279, pl. 50, fig. 7. M. s o l i d a Maurer. Fauna d. rechtsrhein. Unterdevon. 1886. p. 13; Frech. Devon. Aviculiden Deutschlands, p. 143, fig. 15.

Mytilarca is not common in early Devonic faunas. The specimens of the genus from the Dalhousie fauna are well developed in respect to generic characters and of moderately large size approaching in dimensions the Helderbergian species M e g a m - b o n i a o v a t a Hall which has never been well described or figured though its relation to Mytilarca has long been recognized[1]; and in outline and contour M y a l i n a s o l i d a Maurer of the Lower Coblentzian where such species are rare. M y t i l a r c a d a l h o u s i e is elongate subovate in outline, with short straight posterior hinge and long abruptly deflected anterior margin extending to the basal curvature of the valves with a slightly sinuous curve. The surface is regularly but slightly convex with the

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[1]N. Y. State Mus. Mem. 3, p. 89.

greatest elevation along the anterior crescence line and the slope thence gradual in all directions except anteriorly, where it is curved down and inward. The general expression of the shell will be better appreciated from the figures than by description. There are large and small shells present with these characters all representing the same specific form.

The hinge characters are excellently shown in one specimen of the left valve. The beak is terminal; beneath it is the apex of the broad ligament area which is strongly striated transversely.

Mytilarca dalhousie

The anterior edge of this area slopes obliquely back to the inner apex of the valve and at this point is a single oblique elongated tooth, doubly crenulated on the crest leaving between it and the edge of the ligament area a pit or socket for the reception of the tooth of the other valve. This socket is bounded below by a continuation of the tooth. Toward the posterior end of the hinge is an oblique but obscure ridge below the ligament area. This hinge structure is in agreement with Hall's delineation of it for the genus Mytilarca. The umbonal region of the shell is thick and the posterior margin shows successive thickened layers of shell growth.

Lower Devonic. Dalhousie, N. B.

Modiomorpha impar nov.

Shell of small or medium size with straight hinge line not extending for the full length of the valves. Beaks anterior but not terminal, depressed, the umbonal region rising gradually and soon broadening out over the low posterior slope. In front of this ridge

the surface is gently depressed making a distinct sinus in the lower margins specially on the left valve. Anterior margins
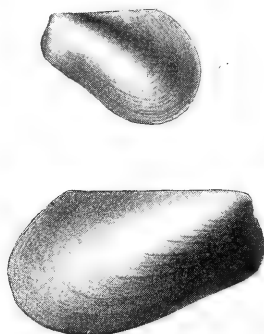
Modiomorpha impar

relatively narrow and blunt, posterior extremity broadly rounded. Postumbonal slope gently concave. Surface covered with regular concentric lines.

Lower Devonic.   Dalhousie, N. B.

Modiomorpha odiata nov.

Shells elongate, depressed convex and of considerable size; beak at the anterior third, hinge short, anterior curvature relatively nar-
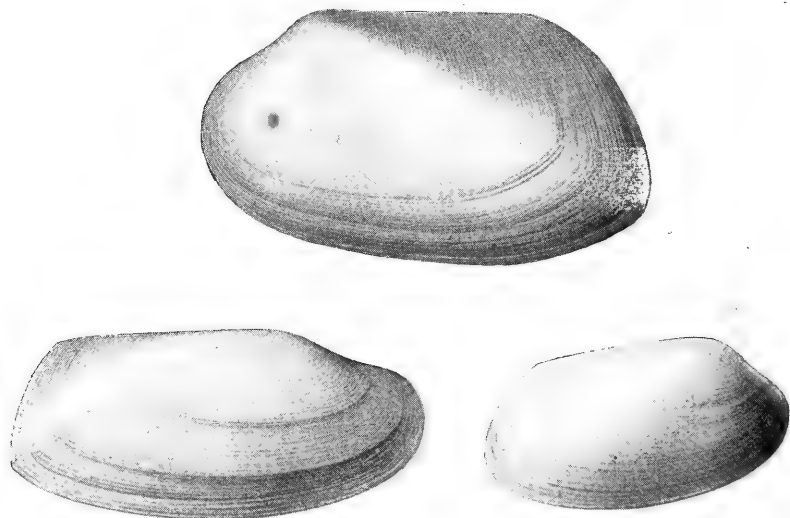
Modiomorpha odiata

row, the valves widening backward in a low very broad curve, umbonal ridge low but clearly defined making a flat or depressed

posterior slope and rather straight posterior margin. Length about twice the hight; actual length of a full sized example 60 mm, hight 35 mm. Surface with concentric lines only.

Lower Devonic. Moosehead lake, Baker Brook point and Matagamon lake, Me.

Modimorpha vulcanalis nov.

Shell robust, with very thick valves; outline short, obliquely cordate, hinge line oblique, beak in front of the middle, not elevated; umbonal ridge low but distinct from which the slope anteriorly is broad and very gently convex while posteriorly it is at first gently concave, then depressed and almost flat near the hinge line. The marginal outline is narrow in front at the ex-
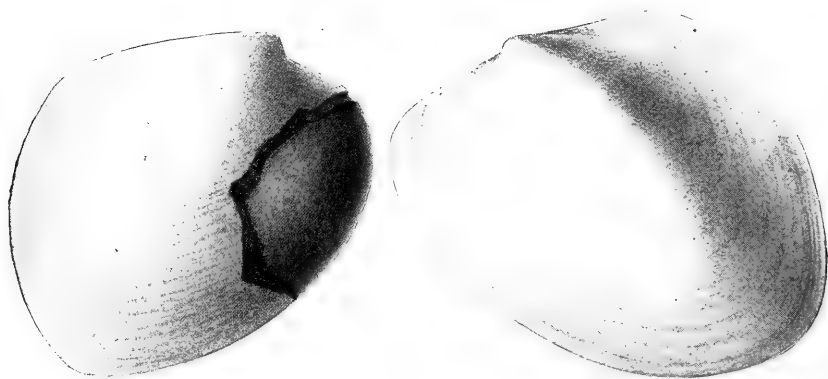
Modiomorpha vulcanalis

tremity of the oblique hinge, widens in a low curve backward, turns almost at right angles at the end of the crescence line, curving thence broadly upward and forward, joining the obliquely elevated hinge in a broad curve. The length and width of the shell are nearly the same.

The resemblance of this species to Drevermann's G o n i o p h o r a
c o g n a t a[1] is very close in all visible features save that the crescence ridge in the latter is somewhat sharper. It may also be compared to M. e l e v a t a Krantz of the lower Coblentzian.[2] Professor Kayser suggests a similarity with M. s i e g e n e n s i s

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[1] Fauna d. Untercoblentzsch. 1902. p. 88, pl. 10, fig. 15, 16.
[2] Beushausen. Lamell. d. rhein. Devons, p. 23, pl. 2, fig. 9–11.

Beushausen.[1]   At all events the short obliquely cordate shell is not familiar in Appalachian fauna of this age.

Lower Devonic.   Edmunds Hill, Chapman Plantation, Me.

Modiomorpha protea nov.

Shell elongate, subrhomboidal, beaks anterior, posterior hinge not elevated, crescence line high, relatively approximate to hinge. Length and hight as four to three. Anterior margin broadly rounded, not narrow, basal margin sloping gently downward to near the umbonal ridge, thence bending up and back in a broad
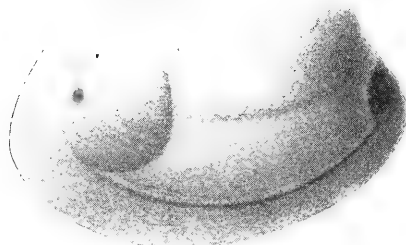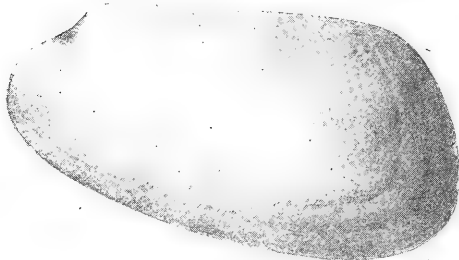
Modiomorpha protea

angle; posterior hinge angle rounded.   Umbonal ridge subangular, sharply defined by the rapid slope of the surface toward the hinge, but not elevated above the general convexity of the sides of the valves.

Anterior adductor scar with the little foot muscle scar well defined.

This species is somewhat variable in outline, some of the specimens assigned thereto being considerably larger than others.   This

[1]*op. cit.* p. 24, pl. 2, fig. 8.

variation, however, is not expressed in the typical specimens at Edmunds Hill as well as in the examples referred to the same species occurring at Presque Isle stream.

Lower Devonic. Edmunds Hill and Presque Isle stream, Chapman Plantation, Me.

Modiella modiola nov.

This is a more elongate, more slender and generally larger shell than M. p y g m a e a Hall, the posteriorly expanded and convex body of the shell being narrower, the byssal sulcus less deep and
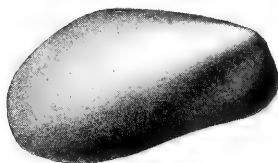
Modiella modiola

the anterior fold very much reduced in diameter. The shells are thus subacuminate or modioloid and very obliquely arcuate. Average examples have a length of 18 to 24 mm.

Middle Devonic. Gaspé Basin, Gaspé.

Grammysia modiomorphae nov.

Shell large, elongate, generally with strong oblique medial depression dividing the valves into two lobes, sometimes a low ridge lying in the bottom of this depression; beaks at the anterior one third of the hinge, slightly elevated, appressed and incurved; hinge line direct, not elevated; marginal outline incurved in front of the beaks, rather narrow at the anterior extremity, broadly incurving on the basal margin at the median sulcus, recurving in a broad angle at the postlateral extremity. The median sulcus varies in width and strength in different examples, at times being highly and somewhat unequally developed on both valves, rather more on the right and again being only a low, broad depression.

Muscle scars obscure, only the anterior adductor being occasionally shown on our specimens. Surface markings concentric striae strongly marked at the anterior margin.

The elongate form of this shell and its subequal extremities give it the appearance of a Modiomorpha. The evidence seems to indicate however that it is a Grammysia of unusual expression,

with which it is not easy to find comparison among other shells.
Drs Kayser and Drevermann who have kindly examined specimens
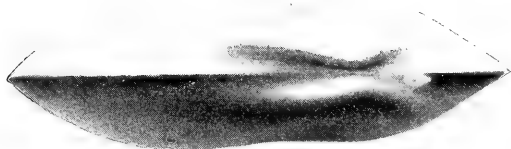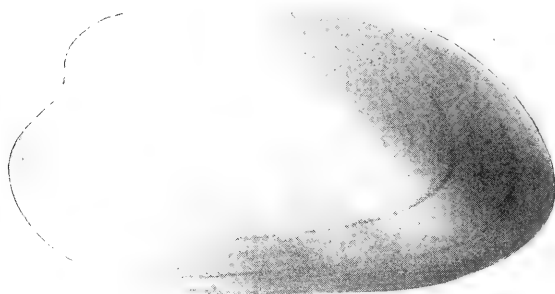
Grammysia modiomorphae

of the shell agree that it is very similar to Beushausen's G.
p r ü m i e n s i s[1] from the upper Coblentzian of the Eifel.

    Lower Devonic. This species is the most abundant of the
lamellibranchs at Edmunds Hill, Chapman Plantation, Me.

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[1] *op. cit.* p. 243, pl. 24, fig. 2-4.

Prosocoelus pes-anseris Zeiler & Wirtgen var. **occidentalis** nov.

The genus Prosocoelus was established by Keferstein in 1857 and was first applied to the species G r a m m y s i a p e s - a n - s e r i s Zeiler & Wirtgen[1] by Beushausen[2] and the latter author subsequently described several species from Coblentzian horizons. The hinge in the genus is characterized by its strong and large, curved umbonal teeth, two in number, with the uppermost the larger, and in the left valve a small triangular anterior tooth; a
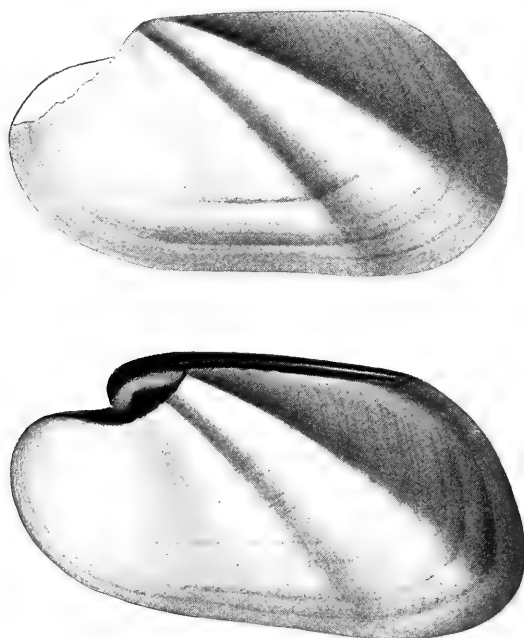
P r o s o c o e l u s p e s - a n s e r i s var. o c c i d e n t a l i s

broad ligament area with longitudinal groove. The exterior bears two or three strong divergent ridges. In P. p e s - a n s e r i s these surface ridges have an extreme of development.

It is of extraordinary interest to find this genus, not before known outside the typical regions of the Coblentzian, present in the fauna of central Maine and by a species which bears so strong a resemblance to P. p e s - a n s e r i s as to make comparison there-with more reasonable than with any other of the known forms.

The shells from this fauna are usually elongate, broader behind than in front, nearly twice as long as high, with two strongly

[1]Singhofen. Jahrb. des Vereins für Naturkunde im Herzogthum Nassau. 1851. p. 290.
[2]Beitr. zur. Kenntn. d. Oberharzer Spiriferensandsteins. 1884. p. 109.

defined radial ridges; the umbonal ridge, separated from the me-
dian ridge by a moderately deep broadening groove and in front
of this a depression bounded by a still lower sometimes quite vague
elevation.   Some of Beushausen's species of Prosocoelus, espe-
cially P. e l l i p t i c u s (Schalke, Hartz) have much the outline
and expression of this shell.   There are specimens in our collec-
tions that indicate a more orbicular outline quite similar to that
of P. o r b i c u l a r i s Beushausen.[1]   I am not altogether certain
whether these represent the latter species or may be compressed
specimens of the former.   The evidence seems to favor the former
view.

Lower Devonic.   Tomhegan point, Moosehead lake, Me.

Leptodomus communis nov.

Shell elongate with a Cimitarialike curve to the hinge, beak
anterior, hinge not equaling the length of the shell; lower margin
sinuate, curving upward posteriorly to a narrowed, subacute ex-

Leptodomus communis

tremity whence the posterior edge retreats to the hinge.   Surface
deeply sulcate from umbo to basal margin.   Umbonal ridge con-
spicuous, blunt and broadly curved, exterior with low irregular
concentric folds.

Lower Devonic.   Presque Isle stream, Chapman Plantation, Me.

Leptodomus corrugatus nov.

Shell small, beak at the anterior third of the hinge, outline sub-
elliptical, posterior slope gently sulcate, smooth, anterior surface

Leptodomus corrugatus

coarsely corrugated and over the median area these anterior ridges
duplicate, there being on the whole on the lateral slope two

[1] ibid. p. 110, pl. 5, fig. 8.

ridges for every one on the anterior surface. Median surface slightly depressed.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Leptodomus prunus nov.

Elongate shells with anterior umbones and low cincture most distinct at the beaks. Surface quite evenly convex though the beaks are depressed. Umbonal ridge broad and ill defined. Ornament consisting of concentric ridges, sharp in the umbonal region
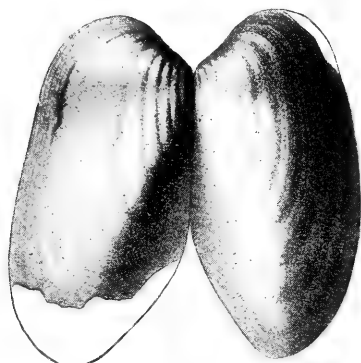
Leptodomus prunus

and with closely crowded concentric lines between all, becoming obscure toward the margins. Length of each valve about twice the hight.

This species is distinguished from L. c a n a d e n s i s Billings of the Grande Grève limestone by its shallower cincture but further knowledge of the species may show its very close relationship to L. s t r i a t u l u s F. Roemer of the upper Coblentzian. [For figures of the latter *see* Beushausen. *op. cit.* p. 265, pl. 24, fig. 12-14]

Lower Devonic. Telos lake, Blind Cove Point, Me.

Goniophora curvata nov.

Shell of medium size, elongate, hinge line usually concealed, but apparently short, not extending posteriorly to within one third of the shell's length of the end. Beaks anterior, subterminal, valve slightly excavated in front beneath them, making the anterior extremity relatively narrow. The umbonal ridge is obliquely curved and lies high on the valves making the postumbonal slope narrow.

The specimens of this shell are not common and it would seem the width of the postumbonal slope and the position of the ridge

are subject to variation by compression.   In forms where this post-
umbonal slope is broader the shell approaches the O r t h o n o t a
s o l e n o i d e s Sow.,[1] of which specimens are before us from the
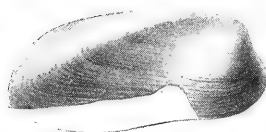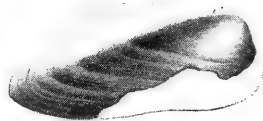
Goniophora curvata

Upper Ludlow of Bradnor lane, Kingston.   The latter shell, how-
ever, is broader and more produced behind and has a shorter and
more oblique hinge line.

Lower Devonic.   Dalhousie, N. B.

Sphenotus ellsi nov.

Shell elongate, subrectangular, hinge line and lower margin
parallel.   Beak at the anterior fourth of the hinge, anterior slope

Sphenotus ellsi

uncurved, anterior margin broadly rounded.   Umbones not ele-
vated, flattened and divided by a sinus or cincture which traverses

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[1]Murchison.   Siluria.   Ed. 3.   pl. 23, fig. 9.

the valves obliquely backward though without greatly affecting the regularity of the basal margin. Umbonal ridge sharply developed, not crested; extending to the postlateral angle. Postumbonal slope broad and concave, its outer edge constituting the entire posterior margin of the valve which slopes forward to the hinge. This concave area is traversed by an obscure radial ridge. Surface of the valves covered with fine concentric striae in low and irregular undulations over the shell body; these however are absent on the posterior slopes where sharp concentric lines alone are visible. Length about one third the hight.

Lower Devonic. Dalhousie, N. B.

Carydium elongatum nov.

This is distinguished from its associate C. g r e g a r i u m Beushausen by its longer and narrow valves which are quite regularly convex from a transverse median line, the surface sloping thence uniformly above and below, leaving the umbones depressed. The
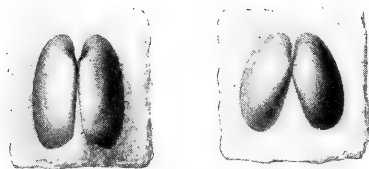
Carydium elongatum

anterior end is visibly narrower than the posterior though the latter is not greatly expanded. The beaks are situated about one third the hinge length from the anterior end and the region in front of the beaks is somewhat excavated. The hight of the shell is about one third of the length. The surface is covered by concentric lines only.

Lower Devonic. Dalhousie, N. B.

Cypricardella norumbegae nov.

Shell short, subrectangular, broader behind than in front, beaks well forward, umbones prominent, umbonal ridge well developed and dividing the valves so as to leave a broad postumbonal slope which is slightly depressed or concave. Hinge line short, not extended in front. Shell margin curving from a broad anterior extremity with an outward bend into the basal margin which becomes direct near the umbonal ridge where it turns sharply

almost at right angles, curving outward, upward and forward and joining the hinge in an obtuse angle.   Hinge with the characteristic
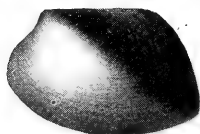
Cypricardella norumbegae

median tooth just beneath and in front of the beak on the left valve.

Shell substance thick, surface with regular concentric growth lines and sometimes a vague radial fold in the postumbonal slope.

Lower Devonic.   Dalhousie, N. B.

Cypricardella parmula nov.

These are small shells of oval outline with an almost uniform convexity, beaks well toward the front and very low umbonal ridge.   They are about one third longer than high and are especially noteworthy for the strong development of the umbonal teeth,
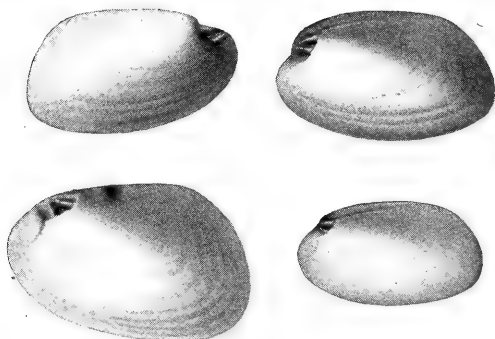
Cypricardella parmula

which are slightly curved ridges, the median one much the strongest, bounded by deep sockets and a more subdued tooth above and below.

There are no Cypricardellas of this type in the New York faunas where they are chiefly characterized by sharp concentric lines and strong umbonal ridge.   Such shells as these are however very closely similar to C. b i c o s t a t a Krantz and C. e l o n g a t a Beushausen,[1] especially to the former.

Lower Devonic.   Moosehead lake, a little north of Soccatean point, Me.

[1] *See* Beushausen's figures, *op. cit.* pl. II, fig. 5-14.

Cypricardinia magna nov.
or cf. crenistriata Sandberger

See Sandberger. Verstein. d. rhein. Schichtensystems. 1850-56. p. 263,
    pl. 28, fig. 5
Beushausen. Lamellibr. d. rhein. Devon. 1895. p. 178, pl. 16, fig. 9-13

Shell large for this genus, somewhat variable in outline but usually obliquely rhomboidal with very strong umbonal ridge, anterior beaks, very decided postumbonal slope which is deeply incurved, narrow anterior extremity widening backward. Hinge somewhat curved, shell extended behind, lower margin slightly incurved and sinuate. Length and greatest hight as six to five, actual length 30 mm, high 25 mm. Some specimens are quite
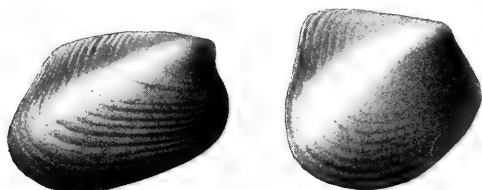
Cypricardinia magna or cf. crenistriata

erect with the hight and length equal. Surface bearing strong concentric lamellose and quite regular sculpture, on which the finer ornamental lines occurring in many other species have not been retained.

This shell in its size and proportions is very closely like C. c r e n i s t r i a t a as figured by Beushausen from the lower and upper Coblentzian of the Rhine. Species in the Grande Grève limestone (C. d i s t i n c t a Billings) attain its size and C. p l a n - u l a t a Hall (Schoharie grit) has a similar contour but no other form than that above cited is known to us which approaches it both in size and contour.

Lower Devonic. Moosehead lake, Baker Brook point, Me.

Cardiomorpha (Goniophora ?) simplex nov.

Shells elongate with anterior beaks; narrow in front, widening behind and with a very high and bluntly angular umbonal ridge behind which is an abrupt posterior slope and in front a well marked sinuosity or radial depression. The posterior extremity of the shell is quite narrow and subacute.

The hinge is well displayed in some specimens and is peculiar for its simplicity; there is a moderately broad striated ligament area which widens slightly beneath the beaks but there is, under the most favorable preservation, no evidence whatever of the umbonal teeth which exist in the typical forms of Goniophora. Therefore the suggestion of relationship to that genus is wholly based on the general aspect of the exterior.   The shell is generally about twice as long as high and many attain a length of 50 mm. Surface sculpture simple concentric lines.   Beushausen referred to Cardiomorpha such toothless shells, including within his diagnosis a large variety of external expressions, among others forms having this Goniophoralike exterior [*see* especially C. a l a t a Sandb. in *op. cit.* p. 223, pl. 25, fig. 15-17].

Lower Devonic.   Moosehead lake, north of Soccatean point, Me.

Palaeoneilo mainensis nov.

Shell attaining large dimensions for a species of the genus, subtrihedral, depressed convex, with beak but little in front of middle of the hinge.   Hight three fifths of the length.   Posterior surface gently sinuate and the postlateral shell margins corres-
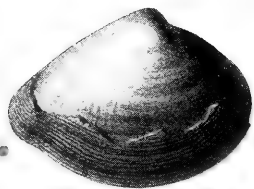
Palaeoneilo mainensis

pondingly emarginate, extremities narrow.   Surface covered with fine concentric growth lines.   On the interior the muscle scars are deeply inpressed, there being on the umbonal side of each a ridge but both anterior scar and ridge are very much the more strongly marked and almost attain the strength of the ridge in Nuculites.

The hinge has the following structure: The posterior arm carries a row of 16-18 ligament pits ending at the anterior edge of the posterior adductor. Those directly under the beak are very slender and transverse, outward they become stronger and more and more chevron-shaped; the anterior arm is not separated by an oblique line from the posterior and carries seven or eight pits, increasing outward rapidly in size and becoming strong and oblique at the terminus near the inner edge of the adductor. In respect to hinge structure, the species is readily distinguishable from P. o r b i g n y i, which it sometimes resembles in form. It is not easy to find European or Mississippian species which this shell resembles in form and hinge structure. Comparisons of similarity are readily made with species of the Devonic on both sides of the Atlantic but these are not helpful in the absence of agreement in critical details. We may however observe that the shell occasionally puts on a concentrically wrinkled surface which we find together with agreements in outline, convexity and, so far as can be ascertained, in hinge structure, expressed in P. m a u r e r i Beushausen and some of its variants in the Coblentzian fauna. [Beush. *op. cit.* p. 85, pl. 7, fig. 11-28]

Lower Devonic. Abundant at Presque Isle stream and 2 miles westward in the burnt district, Chapman Plantation, Me.

Palaeoneilo circulus nov.

Shell small, almost circular in outline, slightly oblique, depressed and evenly convex, with beak somewhat anterior, surface marked
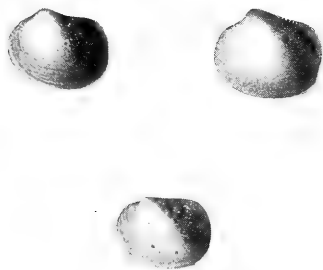
Palaeoneilo circulus

by the fine elevated concentric lines characterizing so many species of this genus and with a very low posterior sulcus. Muscle scars slightly buttressed by shelly ridges.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Nucula cf. krachtae A. Roemer

N u c u l a   k r a c h t a e   A. Roemer. Verstein. des Harzgebirges, 1843.
    p. 23,   pl. 6,   fig. 10
N u c u l a   k r a c h t a e Beushausen. Lamell. des rhein. Devon. 1895.
    p. 47,   pl. 4,   fig. 20

I am disposed to identify with this well known Coblentzian
species a small trihedral Nucula of great obliquity and prominent
overarching beaks.

Lower Devonic.   Presque Isle stream, Chapman Plantation, Me.

Palaeoneilo (Nuculites) folles nov.

This is a species of the type of N u c u l i t e s   b r a n n e r i Clarke
from the Maecurú river[1] and C u c u l l e l l a   o v a t a Sow. from
the Tilestones of Horeb Chapel[2] but while it approaches both of
these very closely there is only the barest indication in the speci-
mens before us of the anterior clavicle shown by a slender de-
pression in the sculpture casts while the other characters of the
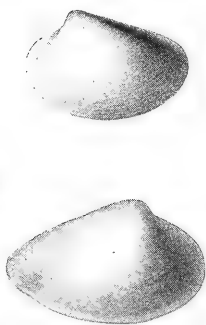
P a l a e o n e i l o   (N u c u l i t e s)   f o l l e s

shell are those of Palaeoneilo, even to the presence of a slight
posterior sinuosity or oblique depression which brings it into com-
parison with P. o r b i g n y i Clarke from Maecurú[3] in which the
surface is covered with very fine concentric lines, and with a num-
ber of more coarsely marked sinuous species from the Coblentzian.

Lower Devonic.   Dalhousie, N. B.

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[1]Archivos do Mus. Nacional Rio de Janeiro. 10: 73, pl. 8, fig. 6-8.
[2]Murchison. Siluria. Ed. 3. pl. 34, fig. 17.
[3] *op. cit.* p. 74, pl. 8, fig. 14-17.

Nuculana (Ditichia) securis nov.

Cf. N u c u l a n a   s e c u r i f o r m i s   Goldfuss (sp.) Petrefacta Ger-
    maniae.   2: 151, pl. 124, fig. 8 and Beushausen, Devon. Aviculiden
    Deutschlands, p. 59, pl. 4, fig. 26-28

Shell small, transversely elongated and snouted, beak approxi-
mately median, hinge line sloping slightly in front, deeply incurved
behind.   Posterior extensions narrow, curved gently upward at the
extremity, anterior extremity broad and blunt; umbones not promi-
nent, umbonal ridge obscure; greatest convexity of the valve anterior
near the hinge; surface generally convex over the body of the shell,
depressed toward the posterior extremity; hinge toothed almost to
the extremity of the posterior extension, while the marginal surface
along the extension is excavated and slightly ridged.   Just within
the position of the muscle scars which are usually faint are two
faint shell ridges or clavicles preserved as grooves on the sculpture
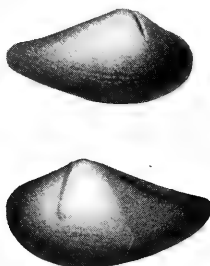
Nuculana (Ditichia) securis

casts. Of these the anterior is the larger, both are broad and low,
but the structure is altogether unusual though not unexpected in
this genus.   This structure is expressed in Nuculites by the strong
development of an anterior ridge and in such forms occasionally
the two ridges appear as in the species N. (C u c u l l e l l a)
e l l i p t i c a Maurer of the Coblentzian for which Sandberger
proposed the generic term Ditichia because of this structure.
Beushausen however considers this development of a second ridge
of only specific value and embraces such species within Cucullella.
For the same reason we may hold the present species within the
genus Nuculana though shells of this lediform type have not before
shown such structures.   The presence of these muscular clavicles
is the only apparent difference between this shell and the N u c u -
l a n a   s e c u r i f o r m i s Goldfuss of the Coblentzian.

The surface of the valves is covered with very fine concentric
striae.

Lower Devonic.   Dalhousie, N. B.

Macrodus matthewi nov.

Shell quite small, obliquely ovate, much broader behind with obliquely curving lower margin and broadly rounded posterior extremity. The hinge is not long and slopes at its posterior end to the posterior curve. The beak is well forward, nearly terminal,
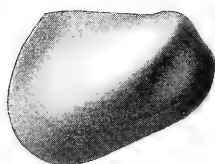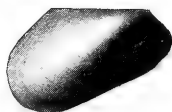
Macrodus matthewi

umbones prominent, umbonal ridge arched, oblique, high, fading out posteriorly. A broad sinus lies medially in front of the umbonal ridge and produces an inward curve on the lower shell margin. Length and posterior hight of the shell nearly the same.
  Lower Devonic. Dalhousie, N. B.

Macrodus ? baileyi nov.

Shell small, elongate, gradually expanding backward. Beaks at about one third the length of the hinge from the anterior extremity. Hinge line rounding broadly backward. Umbonal ridge or crescence line high, posterior, well defined in early growth

Macrodus ? baileyi

but becoming obscure in later stages. Anterior extremity well rounded, the lower margin of the valves incurving medially and rounding again to the broader and rather blunt posterior extremity. The surface of the valves is rendered concave medially by a broad not sharply defined sinus passing from the umbones to the lower margins. Contour quite regularly convex on each side of the sinus.

The length of the shell is somewhat less than thrice the hight. Surface smooth. The hinge structure of this shell has not been definitely determined but the species is provisionally referred to Macrodus.

Lower Devonic. Dalhousie, N. B.

Palaeosolen simplex Maurer

S̄o l e n s i m p l e x Maurer. Fauna d. rechtsrhein. Unterdevon. 1886. p. 18

P a l a e o s o l e n s i m p l e x Beushausen. Lamellibr. d. rhein. Devon. 1895. p. 224, pl. 18, fig. 9, 10

The specimens before us though not abundant in our collections seem to present no distinction from the lower Coblentzian shell

P a l a e o s o l e n s i m p l e x

referred to, and we are disposed to assign them to that species without further question.

Lower Devonic. Moosehead lake, a little north of Soccatean point; also on Presque Isle stream, Chapman Plantation, Me.

Conocardium incarceratum nov.

This species will be found a close ally of C. i n c e p t u m Hall, whose form and surface characters as occurring in the Oriskany of Becraft mountain I have already delineated in New York State Museum Memoir 3. The shell sometimes attains a larger size than the New York species; its form is the same but its exterior differs in the following particulars. The ornament is not so fine, the radial lines less numerous and the deep concentric lamellae can be traced continuously across the shell while in C. i n c e p - t ü m they are so interrupted by the radial ribs on the body of

the shell as to form radial rows of deep meshes which often alternate in their position in adjoining rows. The meshes in C. i n c a r -
c e r a t u m are much the larger transversely. The anterior ridge
is sharply elevated and crested, the anterior slope very abrupt,
excavated and striated by the elevated concentric lamellae which
here take on a radial attitude. The posterior termination is
extended and acute and the valves gape at this end. These specimens show very clearly the structure of the sculpture or prismatic
layer of the shell in these species, which is rendered distinctly
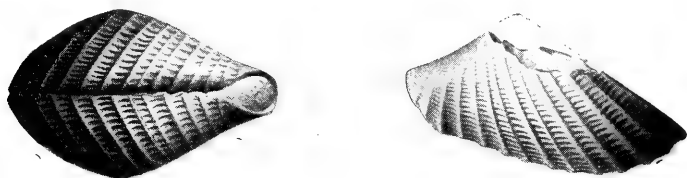
Conocardium incarceratum x3

cavernous by the projection of the concentric growth in the form
of pronounced lamellae rising from the deep intervals between the
ribs and dividing these areas into series of elongate pit-shaped
meshes.

I have been disposed to regard these shells identical with
C. r h e n a n u m as described and figured by Beushausen [*op. cit.*
p. 402, pl. 30, fig. 5–8]. There is agreement between the two in
respect to size, form and radial markings but the lamellar surface
structure is not defined in sufficient detail to determine whether it
corresponds to that of the Dalhousie shell or that of C. i n c e p -
t u m Hall. As there is a palpable difference herein we have preferred to give these shells a distinctive designation. C o n o c a r -
d i u m r h e n a n u m is from the Coblentz quartzite and the Upper
Coblentzian of the Rhine.

Lower Devonic. Dalhousie, N. B.

Lunulicardium ? convexum nov.

Cardiform, beak anterior, outline obliquely orbicular. Surface
convex, elevated about the umbo, which is full and overarched,
abruptly deflected on the anterior slope. Anterior marginal curve
at first concave, thence rounding rather abruptly at the extremity,
posterior curve much broader and postlateral surface somewhat

expanded. Surface bearing round, threadlike and simple radii separated by very narrow sulci. On the single right valve observed
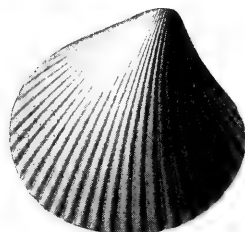
Lunulicardium ? convexum

there are 26–28 of these radii which extend over the entire surface.
    Length and hight equal.
    This is a small shell which, with the general aspect of a Lunulicardium, fails to reveal the critical structural features of that genus.
    Middle Devonic.   Gaspé Basin, P. Q.

BRACHIOPODS

Cryptonella ? ellsi nov.

Shell elongate with relatively slender and projecting umbones and sloping cardinal margins. The beak of the ventral valve is arched but not incurved, the lateral slopes broad and excavated,
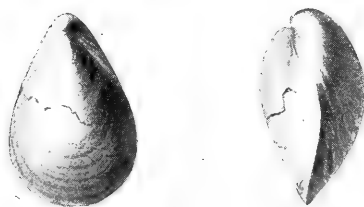
Cryptonella ?. ellsi

bounded without by long cardinal ridges extending one half the length of the shell.   The valves are subequally convex but the ventral valve is flattened toward the anterior margin. Width of valves to length as two to three.
    Lower Devonic.   Grande Grève, P. Q.

Rensselaeria ovoides Eaton (sp.) var. gaspensis nov.

Analyzed as to exterior characters this shell is a miniature of the great R. o v o i d e s of the New York Oriskany, varying in proportion, dimensions, outline and convexity, much as that shell does, that is, frequently high-shouldered and broad across the umbones, rarely broadest in the pallial region, often with lateral margins vertical or slightly introverted specially about the umbones, but as often without this character, usually with the ventral valve medially elevated, and finally with a diversity in the character of
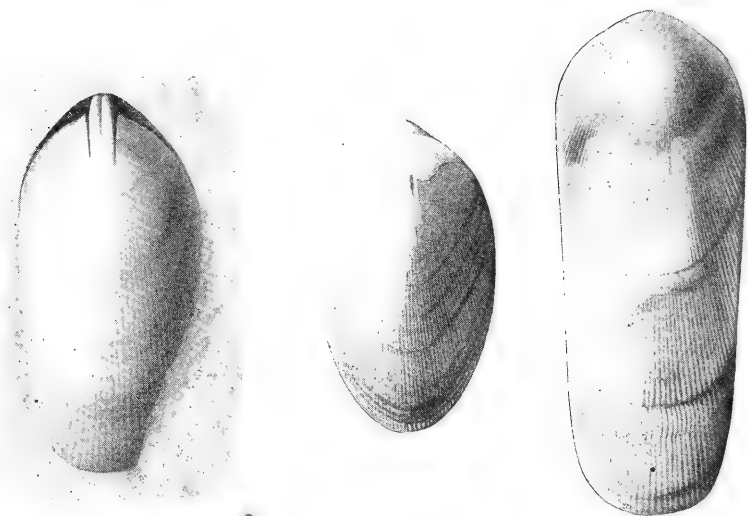
Rensselaeria ovoides var. gaspensis
Left hand figure, Gaspé sandstone; central, Grande Grève; right hand, Percé

surface striation which is due to the fact that the fine striae of early age maintain their simplicity but increase in width without additions, to that in old shells or progressed stages of relatively young shells where the surface may seem to be coarsely marked. On the other hand the shells are characterized by a prevailing narrow elongate-linguate outline with parallel lateral margins for a great part of their length. On the interior there are few notable and perhaps no constant differences, whether in respect to structure of musculature or cardinal plate. It is, however, here important to bring forward the fact which the writer has already expressed with some emphasis, that as between the genera Rensselaeria (as based on the type species R. o v o i d e s) and its chronologic successor Amphigenia, there is a distinction solely in one structural

point. In form and nearly every detail of outline, surface and contour, in musculature, cardinal arrangement, brachial structure so far as known and in intimate shell structure they are homogenic. In Amphigenia however the converging dental plates do not reach the bottom of the valve but first unite and the resultant spondylium is supported on a short median vertical septum. In Rensselaeria the plates converging, fail to unite but meet the inner wall of the shell leaving between them a narrow surface, which is in effect the base of the spondylium. In this special feature which can hardly be accredited with high value as an anatomical differential, there is a definite indication of progress. The Gaspé shells show how frail is this conventional distinction. The convergence of the dental plates leaves only a very narrow space between and quite frequently they come together at the very surface of the shell wall. Even a single vertical septum may develop in the later forms of the Gaspé sandstone. It is natural to compare the small elongate shells from Gaspé with Hall's R. m a r y l a n d i c a from the Cumberland Oriskany. They are shells of the same proportions but in respect to development of the dental lamellae the latter is rather less progressed than R. o v o i d e s .

In view of the evidence presented by these Gaspé shells it seems to us very desirable to regard Amphigenia essentially synonymous with Rensselaeria and indicating as we have said a progressed condition of one feature only. Rensselaeria has many specific expressions and among the forms now referred to it are several more significant departures than that presented by A. e l o n g a t a .

Lower Devonic. Grande Grève and Percé.

Middle Devonic. Gaspé Basin, P. Q.

Rensselaeria stewarti nov.

Shell naviculate, the unequal convexity of the valves being very marked. The ventral valve is highly convex and arched, the line of greatest curvature being median from which the slope is somewhat abrupt to the sides giving the valve a subcarinate exterior. The umbo of this valve is high and overarched, projecting far beyond the hinge line, the apex being incurved and truncate. The cardinal area is represented by a flattened triangular area free of striae and rather definitely delimited. The dorsal valve is gently and evenly convex with low and inconspicuous umbo and beak. The surface of both valves is covered by abundant subequal radial riblets all of which are simple and continuous from beak to margin

except in rare instances where additions are introduced. There is considerable difference in the coarseness of the radial marking in mature shells, the number being as low as 40 and as high as 80 to 90 on each valve.

The radial lines are crossed by exceedingly fine concentric striae. On the interior the ventral valve shows a deep muscle scar and strong dental plates, the former not being striated by the plications
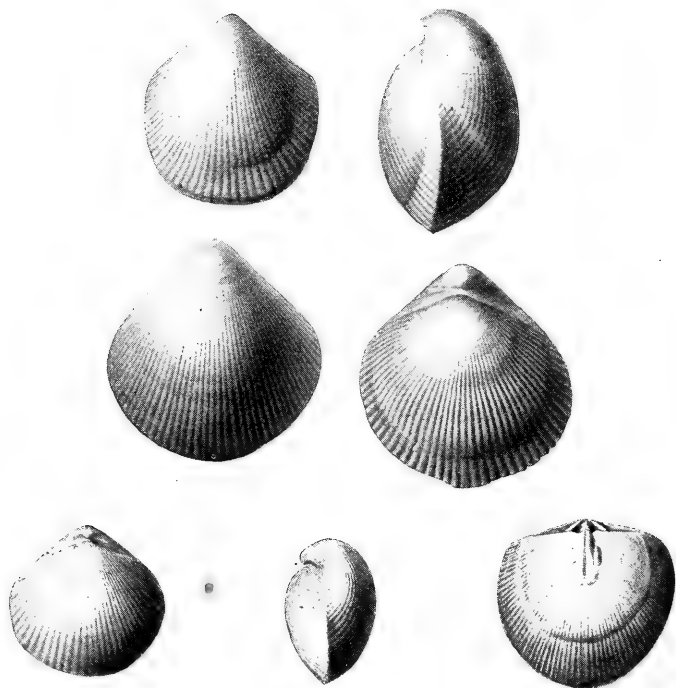
Rensselaeria stewarti
The four upper figures somewhat enlarged

of the shell. On the dorsal valve is a defined cardinal area, perforated hinge plate and narrow elongate muscle area divided by a faint median septum.

We have spoken elsewhere of the relations of this and similar shells to Trigeria and of the presence of such forms both in the Oriskany and Helderberg faunas. We have identified in the Cumberland Oriskany, T r i g e r i a   g a u d r y i Oehlert [*see* Paleontology of New York, v. 8, pt 2, pl. 76, fig. 6, 7] and T. p o r t l a n d i c a Billings from Square Lake, Me. is a somewhat similar shell. Both however lack the specific characters of the shell before us.

Lower Devonic. Dalhousie, N. B.

Rensselaeria callida nov.

On other pages we have entered into some discussion of the species of Rensselaeria of Trigerialike form occurring in Aroostook county and at Dalhousie and have indicated their affinities with the Coblentzian species R. s t r i g i c e p s and R. c r a s s i c o s t a. We have before us now extensive representations of two additional species occurring in association which while presenting some aspects of similarity to the species referred to (R. a t l a n t i c a and
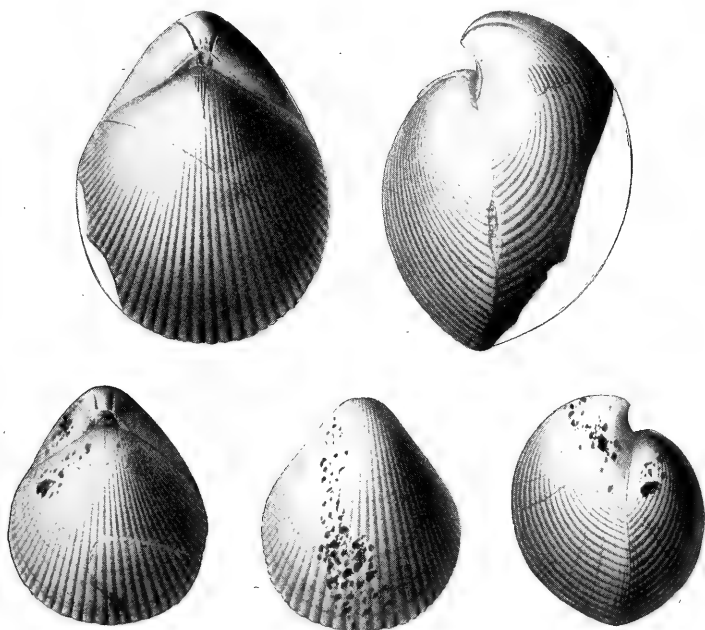
Rensselaeria callida

R. s t e w a r t i) are not in full agreement with them. One of these here designated as R. c a l l i d a occurs in various stages of growth but the adult form is of considerable size, attaining a length of 50 mm and upward. Its valves are full, convex with a tendency to gibbosity, the ventral valve being broadly and faintly keeled and the dorsal valve slightly flattened medially, the ventral umbo elevated and arching but not incurving over the other. The outline is quite regularly oval. Beneath the beak the incurvature shows no evidence of flattening into a cardinal area as in the species cited nor is there evidence of such area on the dorsal valve. There are a well defined foraminal opening and tube and the dental plates are considerably developed extending from one fourth to one

fifth the length of the valve though without thickening. There is no impressed muscular scar and no thickening of the shells in the umbonal region. In the dorsal valve, though there is a median septum extending about one third the length of the shell, there is no thickening at the beak and the hinge plate is so slender that we have been unable to make it out. All these details are in notable contrast to R. a t l a n t i c a, R. s t e w a r t i and the Coblentzian species referred to.

They are in closer correspondence to the Helderberg species R. a e q u i r a d i a t a Hall and indicate, irrespective of their considerable size, an entirely primitive condition of development. The markings of the surface consist of simple rounded or slightly flattened plications seldom with concentric growth lines or other interruptions. There are about 50 of these simple plications on each valve, the number varying very little with size and age.

Lower Devonic. Misery stream, first dam in town of Sandwich; Brassua lake, opposite Moose river, Me.

Rensselaeria diania nov.

This species retains the contour and simple structure of R. c a l l i d a but differs wholly in its exterior which carries 20 to 30
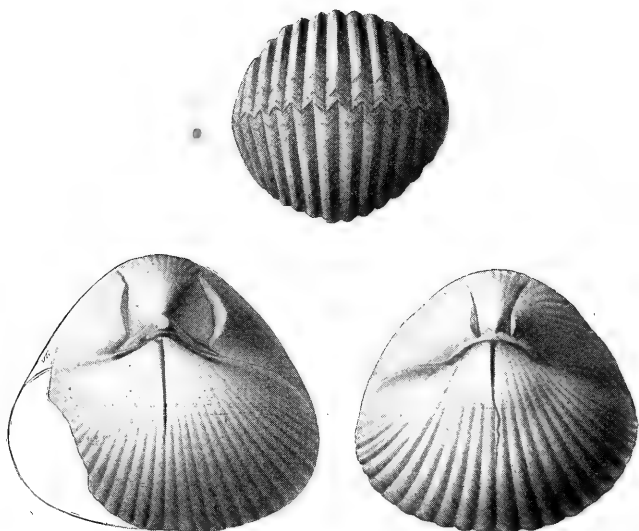
Rensselaeria diania

very coarse and broad, sometimes quite sharply keeled plications which meet in sharp interlocking angles at the edge. Its similarity

to R. c r a s s i c o s t a Koch of the Siegen greywacke is undeniable.

Lower Devonic. Misery stream, first dam in town of Sand-wich, Me.

Rensselaeria cf. crassicosta Koch

See Koch. Neues Jahrb. für Mineral. 1881. p. 237, and other German authors

There are a few shells of small size in a quartzite at the above cited locality which are coarse ribbed and hardly to be distinguished
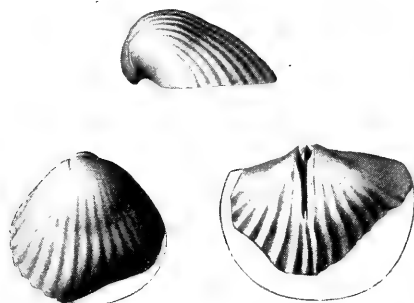
R e n s s e l a e r i a cf. c r a s s i c o s t a

from specimens of R. c r a s s i c o s t a which I have received from Professor Kayser. The dorsal valves show a long and much thickened septum with a divided hinge plate.

R. c r a s s i c o s t a is from the Taunas quartzite and Siegen beds of the Coblentzian.

Lower Devonic. Misery stream, first dam in town of Sand-wich, Me.

Rensselaeria atlantica nov.

R e n s s e l a e r i a m a i n e n s i s Williams, U. S. Geol. Sur. Bul. 165. 1900. p. 80, not described or figured.

The Rensselaerias of the Chapman Plantation faunas are of singular interest for the type of structure they present. They occur both in the Presque Isle stream outcrops and at Edmunds Hill but there is a difference in the forms from the two localities which is expressible in terms of development only.

The Chapman Plantation shells have a naviculoid contour, that is, the ventral valve is highly arched and elevated medially, the beak conspicuous and overarching the hinge, the lateral slopes of this

valve abrupt while the dorsal valve is but gently convex, its beak being so depressed that it is obscure and the valve has a shouldered appearance on account of the broad regular convexity across the posterior part, from which there is a gentle slope anteriorly. The marginal outline is subcircular. In the more progressed type expressed in the Presque Isle outcrops the large and thickened hinge plate is fully developed and was completely perforated at maturity. Likewise the strong adductor muscle scars separated vertically by a low septal ridge have quite the expression they display in fully developed specimens of R. o v o i d e s and they even show the peculiar divergent vascular markings over the posterior

Rensselaeria atlantica

slopes which have been heretofore recorded only in a single example of R. o v o i d e s [Pal. N. Y. v. 8, pt 2, pl. 75, fig. 5].

These are structural features important to emphasize for no other species thus far described reproduces these details of that well known Oriskany shell so well. In the ventral valve, also, mature shells bear the expression of R. o v o i d e s in their fully developed dental lamellae and deep pedicle pit. The shells of this species in early stages are transverse or subcircular rather than elongate, the increase of length being an acquisition of later growth. The hinge line is straight and extends for the full diameter of the shell giving the latter a semicircular outline.

On both ventral and dorsal valves a distinct and prominent cardinal area is present. The straight hinge line extending for nearly the entire width of the valve makes this a conspicuous feature, on the dorsal valve the area maintaining its notable width to the extremity of the cardinal line and then quickly losing it on the hinge angles. In the ventral valve this feature is made

more prominent by the greater elevation of the beak and conse-
quent greater width of the area.

To a certain degree this structure is comparable to that observed
in the subgenus Beachia H. and C. (type, R. s u e s s a n a Hall,
Oriskany, Cumberland, Md.).   In this shell "the cardinal margin
beneath the beak [of the ventral valve] is flattened into a well
defined pseudoarea" [Pal. N. Y. v. 8, pt 2, p. 259].   Here however
is a high development of a cardinal area to a degree far beyond
that expressed in Beachia.   Furthermore in Beachia "the short
inflection of the margin beginning here [on the hinge line] is con-
tinued along the lateral portion of the shell where it meets a similar
marginal inflection from the opposite valve.   These produce the
sharp introversion of the lateral margins which is also one of the
characteristics of the genus Megalanteris."   No such reentrant
margins occur in the shells under consideration.   I would not
refer the species to the subgenus Beachia lest thereby its real
affinities be obscured.

The kindness of Prof. E. Kayser of Marburg has enabled me
to compare my material with typical examples of the Rensselaerias,
R. s t r i g i c e p s F. Roemer and R. c r a s s i c o s t a (Koch)
Kayser, of the lowest arenaceous Devonic of the Rhine, and my
lamented friend, the late Dr L. Beushausen of the Landesanstalt,
Berlin compared some specimens from the Presque Isle stream
fauna with examples of the species mentioned, in the collections
of that institution.

The evidence at hand is very clear that while the specimens
currently referred to R. s t r i g i c e p s are quite variable in
degree of surface striation, yet this species also bears a cardinal
area upon the valves.   This feature is particularly well shown
by a valve from the Taunus quartzite of Katzenloch near Idar in
the Rhine province.   In the main the specimens of this species
are somewhat more finely striated than those from the Presque
Isle but this is a difference notable only in the older shells
where by obsolescence of the lateral striae the riblets become
apparently less.

An internal cast of R. s t r i g i c e p s , somewhat distorted, from
the Siegen greywacke at the iron mine Alte Mahlscheid near Her-
dorf illustrates the immature character of certain of the generic
structures.   Thus the hinge plate and cardinal process are thin
and not perforated, the dental plates and pedicle pit rather incon-
spicuous and the muscular impression not sufficiently strong to
eradicate the marks of the shell plications.   Such an expression of

these structures is immature in the sense that they characterize this primary manifestation of species of Rensselaeria. This is their expression, for example, among the species of the Helderbergian fauna. On the other hand the Rensselaerias from Presque Isle stream are in these respects up to the full development of the type of the genus, R. o v o i d e s. These characters in such condition do not therefore indicate a primitive phase nor an early stage in the history of the genus.

The shells from Edmunds Hill are of more primitive expression, especially in hinge structure, the plate not being thickened though well developed and separated medially or perforated, in this respect having the structure of the early species of the genus, such as occur in abundance in the beds of the Helderbergian of New York. This shell is in a general way smaller and carries within itself the expression of retarded development with reference to the larger forms at Presque Isle. I will not venture the statement that the small forms do not occur at Presque Isle but the larger have not been observed at Edmunds Hill.

The similarity of these smaller forms with the R. s t e w a r t i of Dalhousie is very close yet it seems to me improper to unite the shells, for such union would lead to the identification of the still simpler Dalhousie shell with the progressed form from Presque Isle. At Dalhousie the species seems to have become fixed in its primitive details; conditions in the Chapman Plantation region have permitted progress beyond the expression of R. s t e w a r t i.

The especial expression of the generic type of Rensselaeria afforded by these two closely allied species is repeated in the shell R. p o r t l a n d i c a Billings from the Square Lake limestone of Maine. The last opportunity which the writer had for critical examination of the type of this species was while studying an extensive series of Rensselaeria and brachiopods allied thereto, in the preparation of *Paleontology of New York*, volume 8, part 2. It was then observed that the species T e r e b r a t u l a g a u d r y i d'Orbigny, the type of Bayle's genus Trigeria, was probably present in the Oriskany fauna of Maryland. This is a strongly plicated rensselaeroid, throughout of similar aspect to these under considera-tion save in minor details. To the same group R. p o r t l a n d i c a belongs and in the work cited was referred to the genus Trigeria.

The genus Trigeria means a strongly plicated rensselaeroid with the hinge plate in an elemental condition, i. e. perforated, but with cardinal process slightly developed if present at all, and a cardinal area more or less distinctly retained on both valves. The genus

stands to Rensselaeria (R. o v o i d e s) in the relation of a neanic to an ephebic condition. R. a t l a n t i c a, in its progressed expression even though retaining the primitive structure of the cardinal areas, can not be brought within that group, and Trigeria can not be construed as a valid generic term in the face of the facts here adduced.

In the closest association with the Edmunds Hill and Dalhousie shells are specimens which I have received from Prof. E. Kayser labeled R. s t r i g i c e p s Roem. from the Siegen greywacke, at Siegen (Coblentzian). Though the shell is persistently smaller than those referred to, it is of the same contour, degree of plication and interior structure, emphasizing again the " Trigeria " characters. Precisely what is the relation of this small form from Siegen to the large, elongate, more characteristic examples of R. s t r i g i c e p s from the Taunus quartzite at various localities which bears so strong a resemblance to R. a t l a n t i c a, the writer is not in position to say, but it may prove to be the same as that we have here indicated.

Rensselaeria (Amphigenia) parva nov.

A small, sometimes quite elongate species often presenting the appearance of a miniature of A. e l o n g a t a Conrad. In the

Rensselaeria (Amphigenia) parva

ventral valve the median septum is strong and the spondylium well developed, the lateral surfaces of the bottom of the valve vascular

or pitted. In the dorsal valve there is a large perforated hinge plate, the foramen apparently always open in contrast to the condition of old specimens of A. e l o n g a t a. The external surface is marked by rather strong concentric lines with some radial lines along the middle of the valves.

Lower Devonic. Moose river at Stony brook and Moosehead lake, Baker Brook point, Me.

Beachia amplexa nov.

B. s u e s s a n a and M e g a l a n t e r i s   o v a l i s Hall are two very similar brachiopods in the Oriskany fauna. Whenever a considerable number of specimens of both are available, those of the latter are, as Professor Hall noted in 1859, generally larger, more compressed and proportionally broader. Further differentials are found in the more broadly rounded anterior margin of the latter, the absence of introverted margins except at the cardinal shoulders and a low radial surface striation, coarser but more obscure than in Beachia, and restricted to the marginal regions rather than covering the entire shell as in that genus. The critical distinction in

Beachia amplexa

the genera however is an internal one based on the structure of the cardinal process. These features have been elaborately illustrated by Hall and Clarke[1] whose figures show that in B. s u e s - s a n a this process is distinctly rensselaeroid and consists of two flattened subtriangular plates fused medially and thickened or cushion-shaped at the sides with a median foramen beneath the beak which is closed only by excessive calcification. In M. o v a l i s this cardinal process is stout, subcylindrical, doubly grooved at the extremity and rising from a flat hinge plate, as though in effect the single cylindrical process were superinduced on the hinge plate of a Beachia.

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[1]Pal. N. Y. 1894. v. 8, pt 2, pl. 77.

The shells under present consideration which afford such characters as those specified, are wholesome looking individuals of the aspect of Megalanteris, averaging larger than specimens of either B. s u e s s a n a or M. o v a l i s and yet they have a predominant similarity to the latter. They combine however in most instructive manner the characters of both these species and genera, and we endeavor to express this relation by comparison in tabulated form with the distinctive characters of each.

BEACHIA SUESSANA	MEGALANTERIS OVALIS
Outline elongate	*Outline subcircular*
Margins introverted deeply at side and slightly in front	*Margins introverted but slightly at the cardinal shoulders*
Surface finely striated	*Surface smooth* *Coarse internal striations interlocking at front margins*
Shell punctate	*Inner shell layer punctate*
Cardinal plate composed of two cushioned crural bases cemented medially. Foramen usually open except in old stages. No cardinal process	Cardinal plate flat and thickened bearing a stout cylindrical process doubly grooved at the summit. Foramen lost
Ventral adductor scar shallow and faintly defined	*Ventral adductor scar deep, long, sharply divided*
No vascular markings	*Vascular markings*
Dorsal muscle scar extremely faint	*Dorsal muscle scar well defined and clearly divided*

We may fairly summarize the above by the statement that the shells under consideration essentially agree with M. o v a l i s in all respects save that which has been regarded as the basis of the generic distinction, namely the structure of the hinge plate. Hence the shells are to be referred to Beachia rather than to Megalanteris.

This statement however obscures with words the actual relations. If we analyze the structural features in order of ontogenic values it is evident that M. o v a l i s simply represents a greatly progressed condition of which B e a c h i a s u e s s a n a is a prim-

itive expression and that here concerned an intermediate stage.
Regarding the last named this condition is evinced in a usually
greater thickening of the hinge plate than prevails in Beachia,
and a less strong development of the muscular scars than in
M. o v a l i s.

B. s u e s s a n a is an Oriskany species of the Cumberland basin,
Maryland. The specimen which has been identified therewith in
the Oriskany at Rondout is familiar to the writer but there is no
particular reason for assigning it to Beachia rather than to Meg-
alanteris. The simplest expression of these shells is therefore the
most southerly.

For the sake of an expression therefore the term applied to this
species will serve. It is evident that the generic distinction be-
tween Beachia and Megalanteris is a fugitive one and of little
value. Probably it will be found wise to withdraw the former
term altogether and express the relations here indicated by specific
terms which are even then too exacting. It is not a matter of
record that these species have the same character of brachial
processes but specimens are before me from the Glenerie Oriskany
which show this to be the case.

Lower Devonic. Grande Grève and Percé rock, P. Q.

Megalanteris thunii nov.

Shells having the aspect of M. o v a l i s Hall often with more
convex ventral valve and distinguished chiefly by numerous gen-
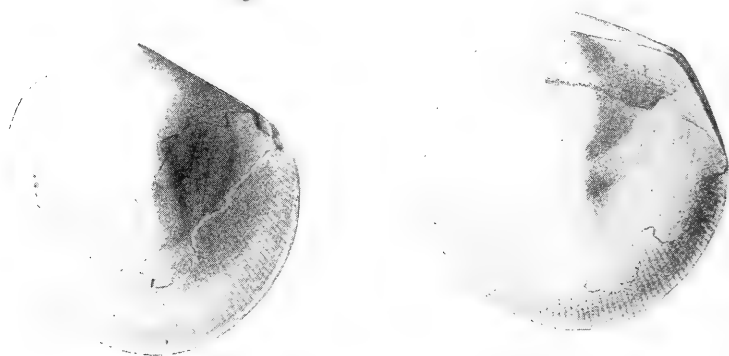
Megalanteris thunii

erally fine radial plications covering the entire surface except the
umbones. This last feature is highly developed and is not con-
nected by gradation with the smooth exterior of M. o v a l i s.

The internal markings are essentially as in the other species, the ventral adductor scar being even more conspicuous, the cardinal plate less developed.

Lower Devonic. Grande Grève and Percé rock, P. Q.

Meristella champlaini nov.

Specimens of Meristella are among the commonest fossils in the Grande Grève limestones. Adult forms of this species share with immature individuals a well defined habit which can be readily distinguished from the known characters of one and another of the many species of the genus which have already been described from the faunas of about this age.

Into immediate comparison with these shells we bring the following known forms: M. l a e v i s, M. a r c u a t a, M. s u b -
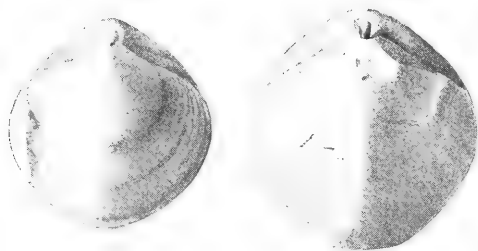
Meristella champlaini

q u a d r a t a of the Helderbergian fauna; M. l a t a and M. v a s - c u l a r i a of the Oriskany fauna. Comparisons therewith are introduced *seriatim.*

M e r i s t e l l a l a e v i s Vanuxem (A t r y p a l a e v i s Vanux, Geol. N. Y.: Rep't on Third Dist. 1842. p. 120, fig. 2; M e r i s t a l a e v i s Hall, Pal. N. Y. 1859. 3 :247, pl. 39, fig. 3, 4; M e r i s t e l l a l a e v i s Hall & Clarke, Pal. N. Y. 1894. v. 8, pt 2, pl. 43, fig. 3-6) is a rather elongate shell with long cardinal slopes making a relatively small angle with each other. Both valves are moderately and subequally convex, the ventral valve faintly sinuate medially in old stages with a broad and rather short linguate extension on the front margin, which when slightly broken, as in most of Hall's figures, gives the front a subtruncate appearance. The dorsal valve has a broadly defined median ridge in all stages, but obscure near the margin in the adult. On the interior there is seldom any trace of vascular impressions departing from the muscular area.

M. c h a m p l a i n i ordinarily has less sloping cardinal margins and it is uniformly a proportionally broader shell. The convexity of the valves is persistently greater and specially so in late stages. Like M. l a e v i s it carries a medial ventral sinus and a dorsal median ridge with depressed lateral slopes, but the linguate extension at the margin is greater. On the interior the vascular markings are highly developed.

M. a r c u a t a Hall [*see* Pal. N. Y. 1859. 3:249, pl. 41, fig. 1a-t; Hall & Clarke, *idem.* 1894. v. 8, pt 2, pl. 43, fig. 1, 2; pl. 44, fig. 5] has a much larger umbonal angle than M. l a e v i s and this is well expressed in M. c h a m p l a i n i. It likewise has the deeper valves of the latter, the ventral being specially curved at the umbo and arched at the beak. Here too we mark the deep lingua on the front margin as large or larger than in the Grande Grève shell. Differences in the two species are obscure but on the whole M. a r c u a t a is less elongate, less sharply ridged on the dorsal valve and the interiors are without vascular markings.

M. s u b q u a d r a t a Hall [*see* Pal. N. Y. 1859. 3:249, pl. 40, fig. 3] expresses a condition in which the form of the shell is squared by the truncation (casual?) of the antelateral margins, making the median dorsal ridge quite prominent, a condition which is sometimes approached accidentally by M. c h a m p l a i n i.

M. l a t a Hall [Pal. N. Y. 1859. 3:431, pl. 101, fig. 3a-w], an Oriskany shell, differs from M. a r c u a t a chiefly in size and the tendency to acquire a breadth unusual to that species. The prolongation of the anterior margin and the depression of the ventral umbo are also distinctive features and in both of these respects the shell is not the same as that in hand.

M. v a s c u l a r i a (described as M. ? v a s c u l a r i a Clarke, N. Y. State Mus. Mem. 3. 1900. p. 45, pl. 6, fig. 12-14) comprises large shells with the proportions of M. l a t a but having the pedicle scar greatly developed and bounded by high dental plates, and the large adductor scar common to all these species obscured almost to obliteration by the pallial ridges and sinuses. The latter are here much more highly developed than in M. c h a m p l a i n i where the muscle scar suffers no obscuration therefrom.

M. c h a m p l a i n i is the designation which, in view of the peculiarities mentioned, we propose for the shells under consideration. It serves to express the fact that they share the features of a series of essentially contemporaneous forms in the American province and at the same time combine these in such a way that,

considered ontogenetically, they are always distinguishable from those, while on the whole most nearly allied to the later expressions in the Oriskany sandstone.

Lower Devonic.   Grande Grève, P. Q.

Athyris hera nov.

The sandstones at Gaspé Basin afford casts of ventral valves, one of them of noteworthy size, of subcircular outline, considerably arched at the umbo but depressed on the slopes, and with a narrow deep and evenly rounded median sinus; the surface of the valve bears only the concentric lines of growth and very fine radial striae visible only in the sinus.   The valve has a length and width of 45 mm.

The larger specimen suggests a Spirifer allied to the rare type of S. l a e v i s of the Ithaca (Portage) fauna of New York, though
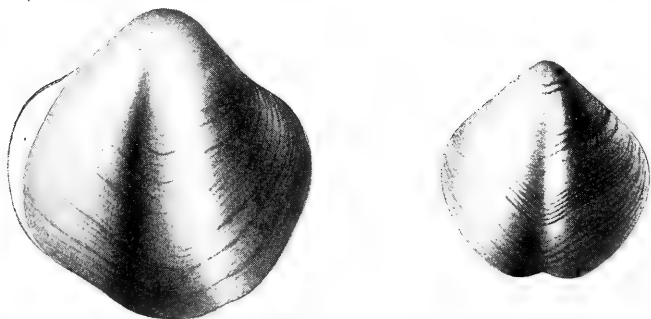
Athyris hera

more orbicular and with more pronounced sinus.   That species has been regarded as a fimbriated shell, but the fine radial lines of this specimen have less the character of fimbriae than of the lines on S. r a d i a t u s Sow. which, without plications, is the starting point of a considerable series of radiate-plicate shells.   The general approach of both our specimens to species of Athyris, such as A. s p i r i f e r o i d e s of the Hamilton fauna indicates a more probable relation therewith.

Middle Devonic.   Gaspé Basin, P. Q.

Spirifer perimele nov.

This is a shell, abundant though poorly preserved in some of the sandstone blocks, which I should identify with S. c a r i n a t u s Schnur were it not for the presence of fine and crowded lamellae

which cover the surface. S. c a r i n a t u s has been often de-
scribed and illustrated from the Coblentzian, most recently by
Kayser in *Fauna des Hauptquartzits,* 1889, page 24, plates 1, 10,
14 and Scupin, *Die Spiriferen Deutschlands,* 1900, page 26, plates
2, 3. S. p e r i m e l e is a shell of medium proportions with rela-
tively narrow cardinal area extending to the full width of the shell;
its fold and sinus are conspicuous and rounded, relatively narrow,
the fold sometimes becoming angular near the front. There are 10

Spirifei perimele

to 12 rounded, closely appressed plications on each lateral slope,
with narrow intervals. The sculpture when well preserved, which
is not often, consists of subequidistant concentric elevated lines
without trace of radii or fimbriae. The interior of the ventral
valve shows a narrow but rather long ovate muscle scar which
is not deeply depressed and is bounded by short dental lamellae.
Fuller description of the shell can not now be given but these
features are sufficient to indicate a dissimilarity with any known
American Spirifer of this horizon.

Lower Devonic. Moosehead lake, Baker Brook point, Me.

Spirifer subcuspidatus lateincisus Scupin

S p i r i f e r   s u b c u s p i d a t u s var. l a t e i n c i s a Scupin. Die
    Spirif. Deutschlands, p. 19,   pl. 1, fig. 13, 14. Palaeontolog. Abhandl.
    1900. v. 8

Under this term is separated by the writer quoted, certain shells
which have heretofore passed as S. h y s t e r i c u s Schloth., among
them those identified by Beushausen from the Spirifer sandstone
of the Kahleberg. It is with these shells, many of which were
collected by the writer in the Hartz when in company with the
late Professor Beushausen, and which are now before me bearing
his label, that I undertake to identify the Spirifer prevailing at
Presque Isle stream. The critical feature from which the varietal
term here used is derived is the long and divergent dental plates
of the ventral valve, l a t e i n c i s u s being a term which has no
significance in application to the organism but only to its me-
chanical surroundings. This Spirifer is a form not represented

in the Appalachian Devonic; comparisons therewith are thus needless. Agreement with the specimens from Hahnenklee and Rammelsberg in the Hartz is found in the following particulars:

1 *Size.* The average in this respect is slightly larger for the adult German specimens.

2 *Outline.* The hinge is not extended, and the cardinal angles not produced; less than or equal to 90 degrees. The margins are gently rounded and gradually approximate to the front. The cardinal area is moderately high and slightly curved making an arched ventral valve.

3. *Plication.* The median sinus in each has the width of five to six lateral furrows. The lateral plications are eight to nine on

Spirifer subcuspidatus lateincisus

each side of fold and sinus and they are narrow, round, separated by furrows of similar width. The concentric markings are growth lines which may show a tendency to rugosity near the front.

4 *Fold and sinus.* The sinus is moderately deep and angulated. It is more sharply angulated on the Maine specimens; in some of the German specimens this angulation is apparent only in later growth. The fold is the counterpart of these characters.

5 *Internal characters.* Most notable independently and in point of agreement are the very long dental plates, which diverge rather more in the German than in the American form. In the Hartz specimens these plates lie uniformly in the first radial grooves and hence diverge at the angle of divergence of the radii. In the American shells they are quite as uniformly subparallel to each other and thus are not parallel with the radii but transect the proximal end of first sulcus and plication. This is a slight but persistent difference. The muscle area in both shells is but faintly defined on the ventral valve.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Spirifer cymindis nov.

This is a shell belonging to an extensive group of early Devonic species which I presume are all minutely fimbriate (as in S. con - c i n n u s Hall) though not in all have the surface characters been

fully determined. Distinctions are refined in this series of fossils and the differentials of the shell before us can best be indicated by comparisons with other members of this series.

In a general way, however, it may be said that S. c y m i n d i s is a shell of larger size and stouter proportions than S. s u b c u s p i-d a t u s   l a t e i n c i s u s of the Presque Isle outcrops. The form is short-winged with a prominent and arched ventral beak, well developed subangular median sinus and fold, the width of the former equaling the distance between three to four radial furrows; of the latter that of three plications. Both sinus and fold have abruptly sloping sides and a narrow bottom and top. The primary plications are conspicuous by their elevation beyond the rest. The radial plications are rounded on the exterior with sharp and narrow furrows, sharper on the internal cast with broader furrows.
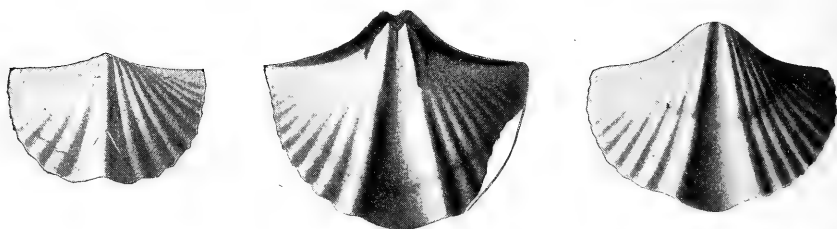
Spirifer cymindis

There are seven to eight plications on each lateral slope. In rare instances there is a faint median plication in the sinus. Fine concentric growth lines with traces of fimbriae cover the surface.

The dental lamellae are short divergent and inconspicuous, the muscle scar of the ventral valve small, well defined, deeply divided by the median sinus. The shell is not greatly thickened about this area and the inner surface adjoining is rarely pustulose.

Comparisons. S. c o n c i n n u s Hall. In this Helderbergian form we have a shell of like proportions but with much more elevated ventral beak and broader cardinal area, more abundant plication, 10 to 12, greater width of fold and sinus and extended projection of the sinus on the anterior margin.

I am here again indebted to Professor Kayser and Dr Drevermann for affording facilities and suggestion for comparison with European species of the early Devonic.

S. a r d u e n n e n s i s Schnur [*see* Schnur. Brachiopoden der Eifel; Palaeontographica. 1854. 3:199, pl. 32, fig. 3; Kayser, Fauna des Hauptquartz. 1889. p. 33, pl. 2, fig. 1-4; pl. 9, fig. 3; pl. 12, fig. 5; pl. 16, fig. 1-9].

This species with which I was at first disposed to identify the shells in hand is usually of small extended form with a very regularly convex ventral valve and broadly rounded plications. Though distinct in outline and contour it often represents the aspect in external and internal surface of S. c y m i n d i s .

S. d e c h e n i Kayser [*see* Kayser. Fauna d. aeltest. Devon-Ablag. des Harzes. 1878. p. 165, pl. 22, fig. 1, 2].

This is a very large species but its smaller expressions, of which I have specimens from the Kellerswald, are like S. c y m i n d i s in degree of plication, though here it is the second rather than the first pair of lateral plications that dominate the rest. The ventral valve is uniformly convex but the umbo is not strongly arched.

S. n e r e i Barrande [as identified by Walther].

Specimens from the upper Coblentzian of Marburg very like this shell in general aspect are somewhat more numerously plicated but a distinctive feature lies in the very long dental plates such as are present in S. l a t e i n c i s u s .

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Spirifer cymindis var. sparsa nov.

Associated with S. c y m i n d i s and quite as abundant, is a shell distinguished in gross by its sparser plication. Our material here

Spirifer c y m i n d i s var. sparsa

presents us chiefly with a series of internal casts in which there are some differences of expression, noted in particular in the following enumeration:

1 *Size.* The shells are of medium size, uniformly approaching S. a r d u e n n e n s i s and S. c y m i n d i s in dimensions. Differences in size and age are expressed on the internal cast by a clearer definition in the younger and thinner shelled examples.

2 *Outline and contour.* The marginal outline is subtriangular, the hinge being long and sometimes extended at the angles, the

lateral margins rather directly convergent. The ventral valve is elevated at the beak, the cardinal area being rather high and curved, and the median part of the shell elevated.

3 *Surface.* The median sinus has a width of from two to two and five tenths lateral furrows, its sides being highly divergent, sloping abruptly to the bottom whch is sometimes quite sharp. The primary plications are conspicuous and elevated. On the sides there are four, rarely five, plications, in extreme cases greatly subordinated to the median ones and separated by broad furrows. The sculpture of the surface consists of rather coarse and moderately distant concentric lines which may become lamellose.

4 *Interior.* The dental plates are as in S. c y m i n d i s . The muscle scar of the ventral valve is deeply impressed and sharply defined, specially in old shells where the test is thickened in the umbonal region. The removal of this thickened shell leaves internal casts with a prominent muscle area, the surfaces adjoining which are pustulose. There is no median septum in this valve. In young shells the ribs are sharp on the internal cast but are rounder on old shells.

The features here summarized constitute an expression not represented in the Appalachian faunas and so far as we can ascertain not exactly reproduced in the Coblentzian.

Lower Devonic. Presque Isle stream, Chapman Plantation, Me.

Spirifer aroostookensis nov.

This shell is characterized by its broad, flat ribs with very narrow, radial furrows, in which respect it is remarkably similar to
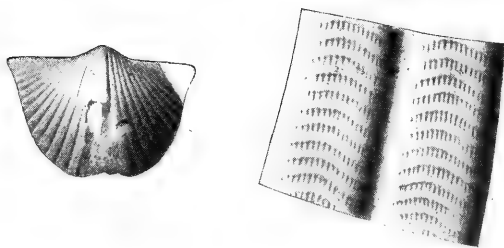
Spirifer aroostookensis

S. m e s a s t r i a l i s Hall of the Upper Devonic (Ithaca group) of New York. Of these lateral ribs there are 10 to 12 on each

side and each of the large ones bears a slight furrow along its flat top. The median fold is relatively narrow and not highly elevated. The shell is short-hinged and rotund in form. The surface is covered with close concentric fimbriate lines which bend backward at the middle of each sulcated rib. I have seen but a single dorsal valve of this interesting species but its differential characters are very distinct.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Spirifer macropleuroides nov.

The Chapman Plantation fauna carries a representative of the Radiati or group of S p i r i f e r p l i c a t e l l u s in a species which has the aspect of a small S p. m a c r o p l e u r a Conrad,[1] an extreme expression of the form presented by S. t o g a t u s Barrande and variety s u b s i n u a t a A. Roemer[2]; the first from the New Scotland Helderbergian of New York and the others from the lowest Devonic of the Hartz and Bohemia.

In S. m a c r o p l e u r o i d e s the shell is more sharply plicate than in the others, the plications being two or three in number
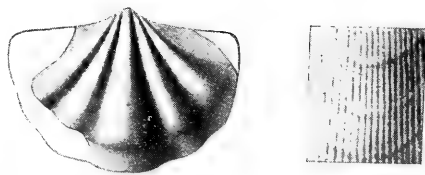
Spirifer macropleuroides

on each side of the median fold or sinus. Neither of the latter is extremely developed, being broad and regularly rounded; the lateral plications are strong and broad, evenly rounded and with narrow grooves. The surface is covered with very fine longitudinal striae. The shell is distinct from S. m a c r o p l e u r a in its smaller size and stronger plications, in which respect it is the most progressed of all the three forms above mentioned.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

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[1] Hall. Pal. N. Y. 3:302, pl. 27, fig. 1a-p; pl. 28, fig. 8a-d. Hall & Clarke. *ibid.* v. 8, pt 2 pl. 21, fig. 22-24, 27.
[2] Kayser. Aelt. Devon-Ablag. d. Harzes. pl. 21, fig. 3 and fig. 1, 2, 7.

Spirifer primaevus Steininger var. **atlanticus** nov.

For comparison consult:

Morris & Sharpe. Geol. Soc. Quar. Jour. 1846. 2: 276, pl. 11, fig. 3. (S. o r b i g n y i)

Steininger. Geognos. Beschreib. der Eifel, 1853. p. 72, pl. 6, fig. 1. (S. p r i m a e v u s)

Sharpe. Geol. Soc. Lond. Trans. 1856. Ser. 2, 7: 206, pl. 26, fig. 1, 2, 5. (S . a n t a r c t i c u s)

Hall. Palaeontology of New York. 1859. 3: 422, pl. 97. (S . a r r e c- t u s)

Kayser. Fauna der aeltest. Devon-Ablagerungen des Harzes. 1878. p. 165, 168, pl. 22, 23, 35. (S. d e c h e n i, S. h e r c y n i a e, S. p r i m a e v u s)

Ulrich. Neues Jahrb. für Mineral. Beil. Bnd. 8. 1893. p. 65, pl. 4, fig. 19, 20. (S . c h u q u i s a c a)

Scupin. Die Spiriferen Deutschlands. 1900. p. 84-88, pl. 8. (S. p r i m a e v u s, S. f a l l a x Giebel,=S. d e c h e n i Kayser, S. h e r c y n i a e Giebel. S. h e r c y n i a e var. p r i m a e v i- f o r m i s)

Clarke. N. Y. State Mus. Mem. 3. p. 46, pl. 6, fig. 26, 30. (S. m u r- c h i s o n i Orbigny)

Reed. An. South African Mus. 1903. v. 4, pt 3, 7, p. 180, pl. 22, fig. 4. (S. o r b i g n y i Morris & Sharpe)

The identity of species in the group represented by S. a r r e c t u s (S. m u r c h i s o n i) and S. p r i m a e v u s, is involved with obscurities of a kind which seem to indicate that in the considerable variety of species names from many countries some are synonymous terms and the majority, perhaps all the rest, are local expressions. The general type of structure is that of a sparsely ribbed Spirifer with the plications usually broadly rounded, a prominent fold and sinus without plication in the latter and the entire surface finely fimbriate. The interior of the ventral valve has a very strong muscular scar appearing in the cast as a sulcate cordiform prominence and the plications lose themselves posteriorly on account of umbonal thickening of the valve. The shells now before us from central Maine are identified as a variety of the widely diffused Coblentzian species S. p r i m a e v u s, not because of structural resemblances that can be fixed upon from the descriptions given of that species and its close allies in the Coblentzian, S. d e c h e n i, S. h e r c y n i a e and its variety p r i m a e v i f o r m i s, but the determination is based on comparisons with specimens of these species from Stadtfeld, Kellerwald and elsewhere kindly supplied and identified by Prof. E. Kayser. These shells are of large size with subtriangular outline, the anterolateral margins being

rather direct and not convex. Usually they are of considerable length fore and aft but specimens are found showing no apparent distortion that are quite narrow and elongate. The hinge is the longest measurement of the shell and the ribs number from 7 to 11 on each lateral slope, the smaller number prevailing in the usual preservation. It may be noted that the first pair of ribs bounding the sinus is the highest as this is in contrast to some specimens of the New York Oriskany classed as S. m u r c h i s o n i , where
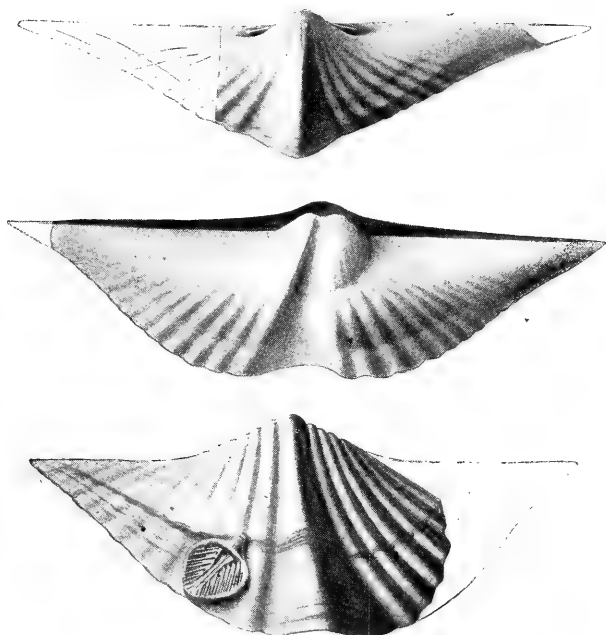
Spirifer primaevus var. atlanticus

the first pair is lower than the second. A comparison of these specimens with those referred to S. a r r e c t u s of the Oriskany by Hall and well illustrated in the work cited, shows that there is a close approach in structure among the larger forms of those. In a previous publication [N. Y. State Mus. Mem. *op. cit.*] I have referred to the probability that the S. m u r c h i s o n i of the New York Oriskany is an unstable form putting on the aspect now of one and now of another species elsewhere localized. Scupin has with more detail pointed out this condition suggesting that some of Hall's drawings are of forms equivalent to S. a n t a r c - t i c u s, S. c h u q u i s a c a, S. o r b i g n y i and S. c a p e n s i s,

from the Falkland Islands, Bolivia and South Africa and that
others, principally the smaller forms express the local value of S.
m u r c h i s o n i.   There are excellent reasons for these views, and
though shells like S. p r i m a e v u s var. a t l a n t i c u s are ap-
parently absent from the New York province yet there is no wide
divergence between them and the larger examples of S. m u r -
c h i s o n i.   It will be understood that a proper interpretation of
the congeries passing as S. m u r c h i s o n i in the Oriskany is
possible only in terms of well defined localized expressions.

Lower Devonic.   Baker Brook point, Moosehead lake, Me.

Cyrtina chalazia nov.

We are presented in these shells with a departure from the usual
aspect of the Devonic Cyrtinas.   They are mostly multiplicate shells
and in the early stages of this time conform quite generally to the
same expression in contour, size and ribbing.   Here we have a
pauciplicate shell, the dorsal valve of which presents the characters

Cyrtina chalazia

which we have noticed as a feature of S p i r i f e r   p l i c a t u s
of the Grande Grève limestones; few, broad and blunt ribs.   The
shells are of the small size quite characteristic of the genus with
trihedral form and erect or but very slightly curved cardinal area,
flat dorsal valve, median sinus and fold well developed, the former
having the width of the next two adjoining lateral plications.   There
are four to five plications on each ventrolateral slope and three to
four on the dorsal, the ones nearest the hinge being always very
faint.   These are in the main broad and smooth and concentric
growth lines are usually crowded near the front margin.

Lower Devonic.   Dalhousie, N. B.

Trematospira perforata Hall var. atlantica nov.

Species of Trematospira are almost exclusively of Helderbergian
age and the species described are pretty well defined on the basis
of their sculpture.   In the form before us we have one more nearly

allied in this respect to T. p e r f o r a t a Hall than to any other though it differs substantially even from that. This shell has the following characters: The ventral sinus is not bounded by the median primary pair of plications but by the primary pair just outside the median, the latter in later growth making a pair on the slopes of the wall of the sinus. Likewise the median rib on the dorsal valve, while constituting the crest of the median fold is accompanied by a pair of ribs of primary age which modify the slopes of the fold. At the beak and continuing for one third the length of the shell without modification the number of plications on the ventral valve is 12, on the dorsal valve 11. From this point outward the ribs irregularly dichotomize into two or sometimes three, fold and sinus being affected like the rest of the surface.

The shell is transverse with straight hinge and without cardinal areas. The ventral beak is abruptly perforate and the shell substance punctate.

Lower Devonic. Dalhousie, N. B.

Chonetes impensus nov.

A large shell having the aspect of L e p t o s t r o p h i a o r i s - k a n i a but with coarser striae. The single specimen observed of this species is a ventral valve, regularly convex, with very fine sub-

Chonetes impensus

equal striae for about one half its length followed beyond a distinct growth line by much coarser striae. Hinge margin cornute, Hight 21 mm, length 28 mm. Specifically unlike any form known to the writer.

Lower Devonic. Moosehead lake, 7 miles north of Kineo, Me.

Chonetes nectus nov.

A small coarse ribbed species, transversely elongate in form and having 14 to 16 striae, each of the larger of which is divided at variable distances from the middle to the margin of the valve. It is but slightly convex compared with C. h u d s o n i c u s Clarke

and does not attain a length of more than 11 mm. A peculiar feature of the species is the general prevalence of a deep con-
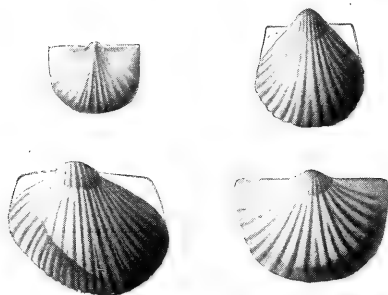
Chonetes nectus

centric constriction in the ventral valve which is present in every such valve yet recognized.

The interior of the dorsal valve is highly radio-pustulate, there being two strong central diverging ribs traversing the valve.

Lower Devonic. Misery Stream, first dam in town of Sandwich; Moose river at Stony brook, Me.

Chonetes aroostookensis nov.

Shell transversely subrectangular, length to width as two to three, hinge line straight, making almost the full width of the shell; cardinal angles 90 degrees or a little more, the lateral mar-

Chonetes aroostookensis

gins expanding gently outward for a very short distance; lateral margins direct at first then broadly curved to the anterior margin which is transverse. Ventral valve gently and quite uniformly convex, somewhat depressed to the cardinal angles. Cardinal area

carrying a row of spines, five in number on each side of the beak, the outer ones attaining considerable length. Surface markings consisting of fine threadlike radii increasing rapidly by bifurcation, the striae and intervening grooves being of subequal size. There are three or four of these in 1 mm. A notable feature is the predominant size of the median stria on this valve. There are also suggestions of concentric or oblique undulation near the cardinal extremities. The surface sometimes shows a broad undefined depression with others at the side which may produce a gently undulated surface. This, however, is not a persistent feature. The dorsal valve is concave and on the interior shows a small bifurcate cardinal process flush with the cardinal area. The sockets and socket walls rest on a greatly thickened ridge just within the hinge line and subparallel to it. This notable ridge has an abrupt posterior slope leading down to the muscular area which is divided by three short and divergent ridges.

Dimensions. The average example has a length of 16 mm, width of 23 mm.

In seeking comparison of this very well defined species with allied forms we may note the following:

With C h o n e t e s   c a n a d e n s i s Billings of the Grande Grève fauna, it is more closely related than with any other, in outline and proportions. Like that it carries a conspicuous median stria. But the species are not to be confounded; C. a r o o s t o o k e n s i s is a stouter and heavier shell with a much coarser surface striation and a more convex ventral valve. It is less delicate and tenuous and never attains the notable dimensions of that species. With C. n o v a - s c o t i c u s Hall from the Arisaig series of Nova Scotia, it agrees in the development of the median stria but the resemblance there ceases. C h o n e t e s   l a t u s v. Buch as identified by Sowerby from the Tilestones of Horeb Chapel, with which it has been compared, has not even remote relation with it. Davidson long ago pointed out that most of the Silurian Chonetes which had been referred to C. l a t u s are identical with C. s t r i a t e l l u s Dalman but he specially excepted the forms from Horeb Chapel. Neither the one nor the other presents any features for comparison here, the Tilestones shell being small, convex and minutely striate. C. s a r c i n u l a t u s Schloth., from the Spiriferensandstein and other horizons of the Coblentzian is somewhat similar in form but is more evenly striate, without large median stria and is notably convex. Schnur's variety of this species, p l a n u s , from the same beds is little known but appears to be a shell of less width.

Of all the species of early Devonic age C. f a l k l a n d i c u s, Morris and Sharpe[1] presents the closest similarity though of smaller size and rather less subrectangular outline.   One might with reason regard the Aroostook species a varietal expression of C. f a l k - l a n d i c u s.   This species has been recently identified in the Bok- keveld beds of Cape Colony and figured by Reed[2] and these figures also show a narrower shell than that under discussion though at- taining its full dimensions.

Lower Devonic.   Edmunds Hill, Chapman Plantation, Me.

Chonetes paucistria nov.

This is a rare shell associated with the foregoing, distinguished therefrom by the fewer and coarser striae, barely more than one half the number in C. a r o o s t o o k e n s i s, increase therein aris-
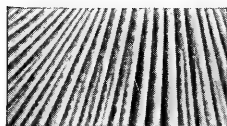
Chonetes paucistria

ing from implantation near the margins. The outline also is not sub- rectangular but subelliptical, the greatest width at the hinge and the margins converging quite rapidly in a broad curve.   These differ- ences are expressed in our figures.

Lower Devonic.   Edmunds Hill, Chapman Plantation, Me.

Chonetes billingsi nov.

C h o n e t e s   l a t i c o s t a   (Hall) Billings. Palaeozoic Fossils. 1874. v. 2, pt 1, p. 20

These shells are characterized by the high gibbosity of the cen- tral region and abrupt slopes to the margins in the pedicle valve and the coarse rounded ribs separated by interspaces of about the same width.   The ribs are usually simple, extending from beak

[1] Geol. Soc. Quar. Jour. 1846. 2: 274, pl. 10, fig. 4.
[2] An. South African Mus. 1903. v. 4, pt 3, p. 169, pl. 20, fig. 9, 10.

to margin and number from 16 or less in small individuals to 26 in the largest shells seen. In full growth of the shell the median rib becomes more pronounced than the rest on the anterior margin and thus makes a low median angle at this margin. Extremely fine concentric lines are visible under favorable preservation. The cardinal area is narrow and only in rare instances are spines retained or developed at the cardinal extremities. On the interior the brachial valve has a small erect V-shaped cardinal process and short thin outer socket walls. On each of the simple coarse ribs which correspond to the furrows of the exterior is a single row of sharp pustules the median row being the most depressed, and the two adjoining the most prominent. No trace of reniform or other lateral depressions is evident. In all such small and coarse ribbed species represented by C. b i l l i n g s i, C. l a t i c o s t a Hall and

Chonetes billingsi

C. m u c r o n a t u s Hall, there is a natural similarity of expression extending even to the interior characters of the brachial valve, but the distinctive differences of C. b i l l i n g s i consist in its gibbosity, angulated front margin at maturity, stronger, coarser and more uniformly simple ribs. In respect to these characters in all the shells they are the most pronounced in that before us and become progressively decreased in the upward range of the group, so that it serves the purposes not only of paleontologic but also of geographic distinction to recognize distinctively this early manifestation of features which are less pronounced in C. l a t i c o s t a of the Onondaga limestone and still further diminished in C. m u c r o n a t u s of the Marcellus and Hamilton.

Dimensions. A full sized example has a width on the hinge of 13 mm. and a length of 11 mm. From this the size ranges downward to a length of 2 mm.

Lower Devonic. Grande Grève, P. Q.

Middle Devonic. Gaspé Basin, P. Q.

Stropheodonta hunti nov.

Shell small, regularly convexo-concave. Ventral valve most convex along the median line, where the curvature is evenly arched and well elevated; lateral slopes depressed, at times slightly concave. Hinge line long, straight, often with cardinal extensions; the length of hinge is to the length of shell as three to two. The surface of the valve is uniformly smooth, usually appearing nacreous and without lineation but well preserved exteriors show an extremely fine radial striation hardly visible to the naked eye. About the umbo are a few low corrugations, three or four in num-
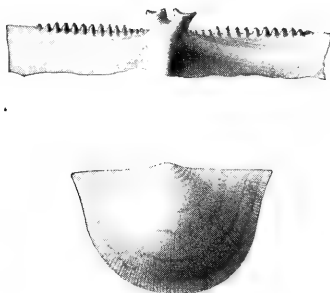
Stropheodonta hunti

ber and these become extinct over the body of the valve. The dorsal valve shows the same degree of corrugation as the ventral and cardinal area of conjoined valves indicates nearly complete closure of the delthyrium and a fine denticulation extending almost to the cardinal angles. The species has been observed frequently.

The shell suggests both in size and in the aspect of its nacreous surface the well known S. n a c r e a from the Hamilton of New York[1] for which Hall and Clarke introduced the subgeneric term Pholidostrophia.[2] Other representatives of this group are known, namely an undescribed shell from the Onondaga limestone of New York and Ohio and probably the S t r o p h o m e n a l e p i s Bronn of the Eifel Middle Devonic.

Lower Devonic. Grande Grève, P. Q.

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[1] According to Schuchert this is the same shell as that described by Owen as C h o n e t e s ?
i o w e n s i s from the Middle Devonic of Iowa and if this is the older species name it should take precedence.
[2] Palaeontology of New York, 1892, v. 8, pt 1, p. 287.

Stropheodonta patersoni Hall protype praecedens nov.

See S. p a t e r s o n i Hall and S. i n e q u i r a d i a t a Hall. Palaeontology
of New York. 1867. 4: 87, 90

Professor Hall noted in his description of the two species cited
above, both from the Schoharie grit and Onondaga limestone that
while in normal forms distinction is readily made, many shades of
transition in style of surface sculpture are found. The shells are
both regularly convexo-concave species with denticulate hinge
with the surface ornament fundamentally consisting of fine elevated
and fasciculate striae, each pair of larger ones including 6 to 10
finer, multiplication of the larger consisting in the superior devel-
opment of the median stria in the fascicle. These lines are finely
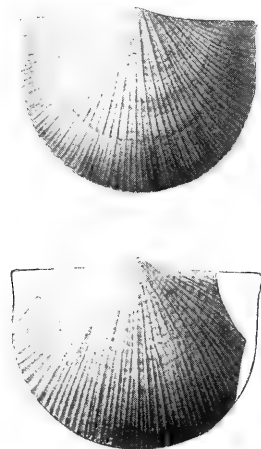
Stropheodonta patersoni protype praecedens

reticulated by concentric elevated striae. Superinduced on this
ornament are, as a species character in S. p a t e r s o n i, con-
centric discontinuous corrugations affecting chiefly the intervals
between the primary striae. These occur faintly and sporadically
in S. i n e q u i r a d i a t a. Billings figures [Palaeoz. Foss. pl. 2,
fig. 3] from division 1 of the Gaspé series, between Cape Rosier
and Grande Grève a specimen identified as S. v a r i s t r i a t a
Conrad in which such corrugated exterior is present, and we have
already commented on this structure. He also insists that there
is no distinction between this shell (and species) and S. i n e q u i-
r a d i a t a except that the former is of smaller size. Compari-
son of typical material representing these species however demon-
strates that notwithstanding the common possession of the cor-

rugations, S. v a r i s t r i a t a is not only smaller but more nearly square in outline with nearly rectangular cardinal angles (S. r e c t i - l a t e r a l i s being one of Conrad's synonyms) while in the other species the outline is more elongate, semielliptical, the lateral and anterior margins form a continuous easy curvature and the cardinal angles are more acutely rounded. These differences produce a notable distinction in the general habit of the species. The Grande Grève limestone shells palpably express the characters of S. i n e q u i r a d i a t a and S. p a t e r s o n i; but in so far as differences in these two are concerned it is to be noted that in the former the fasciculation is best expressed over the middle parts of the shells, but in later growth about the periphery this fasciculation gradually becomes lost or passes into an irregularly unequal striation. The corrugations are restricted to the fasciculate area.

S. p a t e r s o n i, holding its fasciculate character throughout growth, is in an arrested condition with reference to this species. The Grande Grève shells seem rarely to pass the stage in which the fasciculation of the striae is obscured as in S. i n e q u i - r a d i a t a but neither do they always present the corrugations of S. p a t e r s o n i. These corrugations are usually present, sometimes very strongly developed, again obscure, but they may be altogether absent leaving the simply fasciculate exterior so prevalent in the Strophomenidae throughout their history. In view of these facts we prefer to designate the Grande Grève shells as a variation or protype of S. p a t e r s o n i.

Dimensions. Fully developed examples attain a length of 25 mm and a width on the hinge of 40 mm.

Lower Devonic. Grande Grève, Indian Cove and Little Gaspé, P. Q.

Stropheodonta patersoni Hall protype **bonamica** nov.

We have noted the difference in the Grande Grève form of S. p a t e r s o n i and the typical expression of the species in the Onondaga limestone of New York. In the shell before us we have a quite different expression of this type, rare in American waters. The type itself, we may briefly reiterate, is expressed in the highly convex form, the strong fasciculation of the striae and the corrugation of the umbonal portion of the valves. We are here presented by a relatively small and quite narrow shell with a short, straight hinge, prominent cardinal extremities, highly convex or gibbous curvature (ventral valve) and greatly produced

anterior margin. These are distinctly mutational characters which constitute very notable differences in the shells. The surface characters are more distinctly indicative of progressional phases of development and may be thus tabulated for the three different expressions of the species:

Primary fascicles at the beak $\begin{cases} \text{19–25 p a t e r s o n i} \\ \text{10-14 p r e c e d e n s, b o n a m i c a} \end{cases}$

Intercalation of striae apicad of summit $\begin{cases} \text{frequent—p r e c e d e n s} \\ \text{less frequent—p a t e r s o n i} \\ \text{occasional—b o n a m i c a} \end{cases}$

Anterior slope $\begin{cases} \text{finely and} \\ \text{subequally lobed—p a t e r s o n i, p r e c e d e n s} \\ \\ \text{coarsely and} \\ \text{strongly fasciculate—b o n a m i c a} \end{cases}$
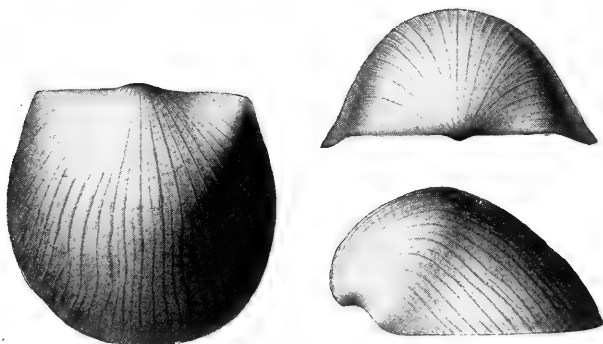
Stropheodonta patersoni protype bonamica

The umbonal corrugation appears to be differently developed according to individuals, but generally is coarsest in p r e c e d e n s, smaller and more numerous in p a t e r s o n i. The summarized evidence indicates the phylogenetic relation of these species to be thus: b o n a m i c a retains the most primitive expression throughout supplemented by the character of its hinge which is denticulate only near the delthyrium; p r e c e d e n s is still more primitive than p a t e r s o n i in respect to striation, but less so than b o n a m i c a. The relation indicated seems to be in accordance with the actual time relations of these shells.

Students of the Brachiopoda recognize in the fasciculate-crenulate type of surface structure a recrudescence in these early Devonic shells of characters which appeared among the Strophomenoids in the Lower Siluric and except for the crenulation became prevalent. This later expression is never common nor did

it last long. The typical S. (O r t h i s) i n t e r s t r i a t u s Phillips is shown by Davidson[1] to carry at times the umbonal crenulations and the large and fine S. n o b i l i s McCoy[2] exemplifies both characters in very simple expression, both of these species being recognized as of Middle Devonic age. The former species is commonly regarded as present in the Eifelian.

Lower Devonic. Dalhousie, N. B.

Stropheodonta rosieri nov.

This is a small shell characterized by its simple, relatively coarse and highly angular plications which increase by implantation starting with 8 to 10 at the beak and becoming twice that number at the margin. Over these and in the intervals are fine radiating
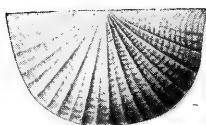
Stropheodonta rosieri

surface lines. The umbonal region is crenulated by undulating concentric lines which may sometimes extend over the whole surface. The shells have thus some of the characters of S. p a t e r - s o n i p r e c e d e n s of the Grande Grève limestones and of those known in the New York rocks as S. v a r i s t r i a t a , but the divergence from either is apparently fixed.

Lower Devonic. St. Alban beds, Cape Rosier Cove, P. Q.

Stropheodonta crebristriata Conrad (Hall)
protype simplex nov.

See Hall. Palaeontology of New York. 1867. 4:86, pl. 11, fig. 12, 13, 18-21

On comparing with the hypotypes of this species illustrated in the work cited, a few shells from Grande Grève, we observe that

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[1] Monogr. Brach. 85, pl. 18, fig. 15-18.
[2] *idem.* p. 86, pl. 18, fig. 19-21.

the young condition of S. c r e b r i s t r i a t a (a Schoharie grit species in New York) represented by the original of plate 11, figure 13 [*op. cit.*] corresponds remarkably in size, contour and surface with these. The shells in hand are quite regularly convex having the greatest width along the hinge, a semielliptical marginal outline and the surface bears 8 to 10 sharp angular but not elevated plications, which increase in number by implantation so that the margin bears at least four times as many plications as the beak. In S. c r e b r i s t r i a t a , as referred to, there are about the same number of plications though they are individually less prominent and their duplication begins somewhat earlier. This specimen shows a fine interlineation which we observe only at the margin of the Gaspé shell.

We construe this shell as a simple and early expression of S. c r e b r i s t r i a t a , probably not attaining greater size or more progressed development in surface feature than expressed in our specimens.

Dimensions. Length, 13 mm; width on hinge, 16 mm.

Lower Devonic. Grande Grève, P. Q.

Stropheodonta parva Hall protype avita nov.

See Hall. Palaeontology of New York. 1859. 4: 85, pl. 11, fig. 5, 11

Several brachial valves show at first the median groove and four to five simple strong ribs on each side, such as characterize S. g a l e a t a Billings and change this expression by the simple bifurcation of these ribs at about one half their length, and, close upon the margin, by the subdivision of one or the other of these branches. This is the character of S. p a r v a Hall of the Schoharie grit of New York, a rare species, and comparison of the Gaspé shell with the single exterior of the brachial valve figured or known [*op. cit.* pl. 11, fig. 5] shows similarity of dimensions to be accompanied with the like character of surface. In S. p a r v a the ribs are not so strong and bifurcation begins sooner, that is, the period of simplicity continues longer in the Gaspé shell and hence gives it more primitive expression, in accordance with its antecedent date.

Lower Devonic. Indian Cove, Gaspé, P. Q.

Leptostrophia tardifi nov.

Shell of uniformly medium size, averaging about that of L. p e r p l a n a (Conrad); flat or broadly convex in the umbonal

region, hinge line straight and not extended, commissural margin
subcircular. Surface radii numerous, composed of rounded lines
with very narrow interspaces, the former increasing quite irregu-
larly by bifurcation but keeping a subequal appearance throughout.
The surface seems to have been early subject to irregular growth
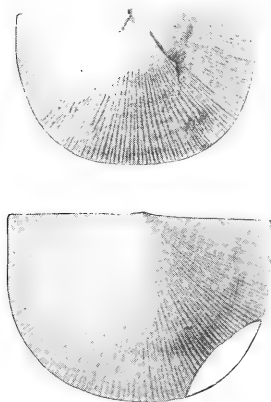
Leptostrophia tardifi

from injury or pathologic condition of the mantle, rapid duplica-
tion of the striae following each of these cicatrices. These striae
are covered by extremely fine concentric lines. Attention is
directed to the differing expressions of the surface markings on
these allied species, L. t u l l i a Billings, L. m a g n i f i c a Hall,
L. i r e n e Billings and L. t a r d i f i.

Dimensions. Average specimen 35 mm in width on the hinge,
length 25 mm.

Lower Devonic. Percé rock, P. Q.

Leptostrophia magnifica Hall protype **parva** nov.

This shell may be best expressed in terms of the widespread
L. p e r p l a n a Conrad and L. b l a i n v i l l i i Billings, for it
approaches these in all general features. Analysis of its structural
details however shows:

1 The surface striae, fine, threadlike and crowded, exhibit some
diversity of size in early growth and this becomes intensified later
so that about the margins there is either an inclination to irregular
swelling or to fasciculation, the latter at times being quite pro-

nounced. These are characters of L. m a g n i f i c a not of L. p e r p l a n a . Concentric wrinkles on the shell are altogether absent.

2 The cardinal area is denticulate to its extremities though narrow and but slightly cross striated; the delthyrium is open.

3 The muscle scars are not greatly divergent but, as in L. m a g - n i f i c a , are contracted at the beginning though they extend more than halfway across the shell.

The shell is essentially a diminutive expression of that species, its fundamental structure being quite in harmony with it and its
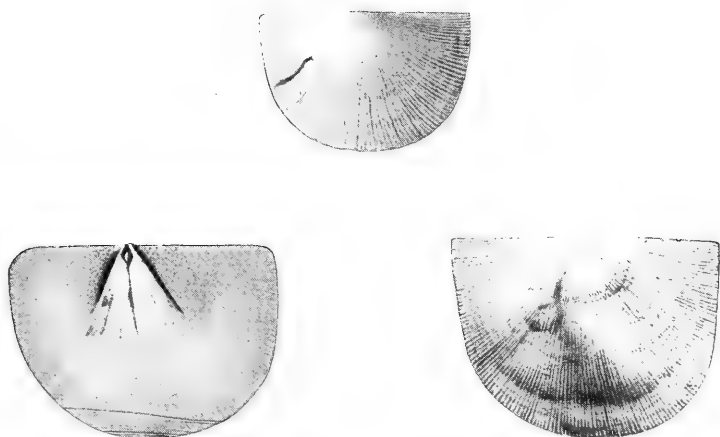
Leptostrophia magnifica protype parva

lesser variety t a r d i f i from the Percé rock. In our material an occasional specimen indicates the presence of individuals larger than these we have figured. Dr Drevermann, after examination of these specimens, finds this shell closely approaching L. e x - p l a n a t a Sowerby of the Coblentzian though that shell attains more nearly the dimensions of L. m a g n i f i c a and has flatter rather than threadlike striae on the surface.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Strophonella (Amphistrophia) continens nov.

S t r o p h o m e n a p u n c t u l i f e r a Conrad, var. Billings. Palaeoz. Foss. 1874. v. 2, pt 1, p. 32

Shell rather strongly concavo-convex, the normal convexity of the ventral valve being continued for about one third the length of the shell. The reversal is gradual but becomes abrupt specially

in final stages. The hinge line is straight and the cardinal angles
very slightly extended, subangular or even rounded; cardinal area
narrow, not striated vertically, denticulate but slightly and only
near the delthyrium of the ventral valve. The opposite valve
receives this denticulate edge in a narrow crenulated groove. The
muscle scar of the ventral valve is short and broadly flabellate with
somewhat thickened and elevated margins. The deltidium is
usually but partially developed. In the brachial valve the cardinal
process is strongly bifid, the separate parts being widely separated;
dental sockets shallow.

The surface of the valves is marked in the umbonal region by
16 to 20 sharp angular plications, simple throughout the normal
contour of the valves. These primary plications with those of
the secondary series eventually constitute over the body of the
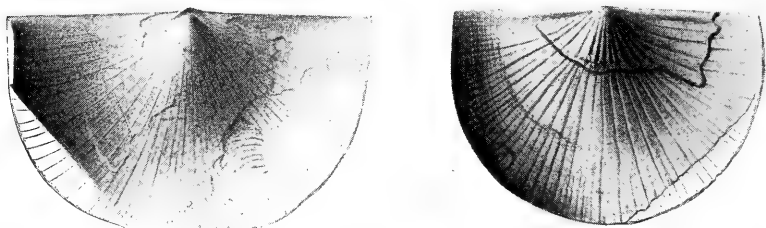
Strophonella (Amphistrophia) continens

shell a series of fine threadlike lines separated by flat spaces in
which lie fascicles of lesser order, sometimes but a single series
consisting of six or more lines, sometimes three or more subordinate
series. The general expression of the surface ornament however
is that of fine sharply fasciculate striation. On the interior of the
valves the surface is highly pustulose throughout except on the
muscle areas, the pustules being arranged in radial rows.

These are the usual characters of the adult shell. The young
of the species are readily recognized as normally convex shells
with sharp and strong plications and this is a condition which when
maintained to maturity is expressed in such species as S t r o p h e o-
d o n t a a r a t a of the Schoharie grit of New York.

Variant 1 e q u i p l i c a t a. We find a few of these forms in
which the simple sharp plication of growth is not broken up into
fascicles but continues sharp over the body of the shell with very
sparse intercalations, so that the surface conveys the expression
of subequal plication and not of fasciculation. Such forms are
at once distinguished by their exterior. The initial striae are a

few more in number than in the normal of the species, but the variation may be interpreted as one due to the protracted continuity of the simple plicated condition of infancy.

Variant 2 s e n i l i s. Occasional expressions occur in which the fasciculation becomes well pronounced as a secondary condition following the sharp plication of early growth but finally is obscured or lost by rapid intercalation so that the peripheral surface carries a great number of fine subequal radii. This expression doubtless represents the extreme development of the specific characters beyond the point usually attained in the normal growth of the species.

Variant 3 e q u a l i s. Again, in certain full grown shells the primitive coarsely plicate stage is so early suppressed as to be scarcely noticeable and fasciculation is at once inaugurated and continued throughout the shell growth. This is a very early assumption of mature characters unaccompanied by evidences of senile growth in final stages.

Lower Devonic. Grande Grève, P. Q.

GASPESIA gen. nov.

Gaspesia aurelia Billings *sp.*

O r t h i s a u r e l i a Billings. Palaeoz. Foss. 1874. v. 2, pt 1, p. 34, pl. 3, fig. 3

The singular valves which Mr Billings described under the name cited are strophomenoidlike shells with straight hinge extending the full width of the valves, central beak, which is slightly produced beyond the hinge line, a generally semielliptical outline, and the surface marked by sharp distant and sparse radial ribs. The
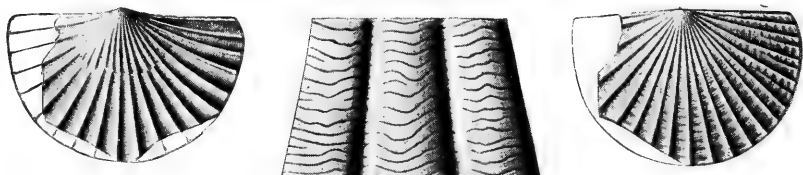
Gaspesia aurelia

substance of the shell is tenuous and none of the specimens shows any trace of hinge structures or muscle scars and none were noted by Billings. Billings remarked that the shell " closely resembles O. p e c t i n e l l a Conrad of the Trenton limestone." In the apparent suppression of hinge structure we have suspected the affiliation of this species with the nearly symmetrical and thin-

shelled lamellibranchs of the genera Halobia and Daonella and yet
there is no positive evidence that the beaks are not axial nor of
any specialized anterior part which can be construed as an auricle.
They are probably to be regarded as an aberrant strophomenoid,
slightly convexo-concave, but the character of the shells is so
peculiar as to prevent their admission to any of the recognized
brachiopod genera.   The strongly ribbed surface bears from 20
to 25 narrow radial plications separated by broad flat sulci which
in old shells may show traces of intercalary ribs but the primary
ribs are all simple.   These interspaces are crossed concentrically
by wavy inosculating elevated lines like the fine lines on many
crustacean carapaces.   We should not venture to say that the
shells are of Siluric type for the comparison made by Billings is
only remote, but there is a certain similarity both in form and
sculpture to the species described by Hall and Clarke as O r t h i s
? g l y p t a from the Niagaran dolomites of Milwaukee [*see* Pal.
N. Y. 1894. v. 8, pt 2, p. 359, pl. 84, fig. 8, 9] which has been
compared with O. l o v e n i Lindström from the Swedish Upper
Siluric.   One of the specimens appears to have cardinal spines
near one extremity but this appearance is probably misleading as
the shell may have here suffered an injury which has distorted
growth.

Lower Devonic.   Grande Grève, P. Q.

Hipparionyx minor nov.

The recognized distinction between the genera Hipparionyx and
Orthothetes or Schuchertella lies chiefly in the orthoid form of
the former and its very short hinge line.   In respect to this char-
acter the specimens before us are pronounced.   The ventral valves,
small in comparison with those of H. p r o x i m u s , have a short
and low cardinal area, but in the dorsal valves the hinge line is
apparently longer than correspondence with the opposite valve
requires and these valves convey the impression of a straight and
tolerably long line extending more than one half the width of the
shell.   On examination of the inner surface of this valve it is
seen that this area is really short and confined to the apical part
of the valve while the extended extremities are a thin expansion of
the lateral parts of the valve which make a rather sharp turn at
the cardinal angles.   There is other divergence in the shell away
from the type of Hipparionyx and toward that of Orthothetes as
represented by such shells as S t r e p t o r h y n c h u s u m b r a c -
u l u m Schlotheim and its variant expressions.

In further detail, the ventral valve is subcircular or transverse
with strongly defined and thickened adductor and divaricator scars.
These are not however as large as in H. p r o x i m u s . The
beak is convex and slightly elevated but the rest of the valve is
depressed or flat with a tendency to turn up about the margin and
with indications of a broad and low median fold. The striae are
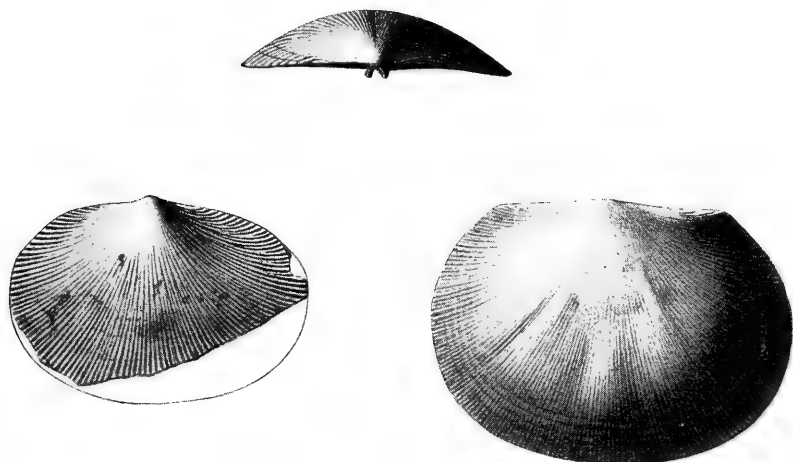
Hipparionyx minor

sharply elevated, increase very rapidly by implantation and on the
cardinal slopes curve forward, out and back, in very characteristic
manner. Very fine concentric lines are visible in the intervals
between the striae. The dorsal valve is highly convex; the beak
is not prominent, the convexity is generally uniform with slightly
depressed cardinal slopes and sometimes a trace of a median groove.
On the interior is a strong bifid cardinal process and a short median
septum.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Orthothetes (Schuchertella) woolworthanus Hall
mut. gaspensis nov.

See S t r o p h o m e n a w o o l w o r t h a n a Hall. Pal. N. Y. 1859.
    3: p. 192, pl. 17, fig. 1, 2 ; and
O r t h o t h e t e s w o o l w o r t h a n u s Hall & Clarke. Pal. N. Y.
    1892. v. 8, pt 1, pl. 11, fig. 25-29, 31

It is not easy to discriminate species differentials in members of
the genus Schuchertella (Orthothetes). In the forms before us
we are presented with a shell which approaches in general aspect

O. w o o l w o r t h a n u s of the Helderbergian (New Scotland) shaly limestone; it has the long and straight hinge, subsemicircular rarely subelliptical outline, sometimes elongated and in the character of the surface there is comparatively little difference. We observe, however, that in O. w o o l w o r t h a n u s the ventral beak is rarely greatly elevated and distorted while this distortion is present in mut. g a s p e n s i s, giving the valve at times the aspect of O. d e f o r m i s Hall (New Scotland beds). The shell substance is much the thicker in the mutation and the pallial surface is vascular. In the dorsal valve the muscle scar of the mutation is larger, sharply subdivided and the pallial surface strongly marked with impressions of mantle vessels, the trunks of which are median, departing forward from the front end of the muscle area. In O. w o o l w o r t h a n u s the shell is so thin as to seldom show these scars. In both valves the plications are sharply defined about the periphery. On the exterior the mutation shows a rather regular inequality in the striae which in total are probably less in number. The differences are sufficient to indicate a modification of the earliest type expressed in S. w o o l w o r t h a n u s.

The shell attains considerable size, fully that of large examples of O. w o o l w o r t h a n u s.

Lower Devonic. Grande Grève and Shiphead, P. Q.

Rhipidomella logani nov.

Prob. O r t h i s o b l a t a Logan (Billings) Geol. Can. 1863. p. 393
O r t h i s l i v i a Billings (in part). Palaeoz. Foss. 1874. v. 2, pt 1,
    p. 32

Lens-shaped, subcircular shells, subequally convex in the posterior region, the ventral valve depressed anteriorly while the dorsal maintains its convexity. The slope of the surface of the dorsal valve is even in all directions and much more abrupt than in the ventral valve, the former is hence considerably the deeper valve. Little value can be laid upon the characters of the external markings which are in all these species fine, subequal, rounded and sharply elevated lines.

In the ventral valve the cardinal area is high and rather narrow, the delthyrium broad and the teeth well defined but not conspicuously elevated. The adductor scar is broad and flabelliform, extending one half the length of the shell and inclosing narrow and elongate oval diductors. The pallial region is well marked by pallial ridges which inosculate freely.

In the dorsal valve the cardinal area is narrow and not long enough to materially modify the almost circular outline of the valve. The crural processes are conspicuous and divergent and the car-
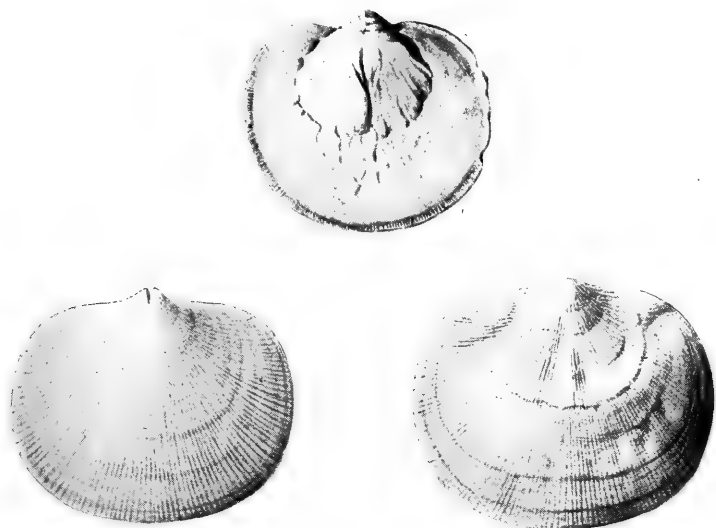
Rhipidomella logani

dinal process rather diminutive, curved forward, trifid at its end which does not project beyond the hinge.

In size, a width of 34 mm and a length of 29 mm is an average maximum and the limit of variation in size is not far from this.

Lower Devonic. Grande Grève, P. Q.

Rhipidomella lehuquetiana nov.

Shell small lenticular or subplanoconvex. General outline subcircular, a little wider than long. Ventral valve depressed, beak generally obscured or resorbed, umbo depressed; a broad and low sinus begins in the umbonal region, widens outward and becomes deep on the anterior margin making a strong sinuosity or tongue extending upward into the other valve. The surface at the sides of the sinus is broad and flat except about the margins where it is more abrupt.

Surface radii fine, rounded, numerous and subequal and cardinal area moderately high and curved downward at the sides. On the

interior the delthyrium is relatively broad and has encroached upon
the beak, the pedicle cavity is deep, the teeth stout and thick.   The
adductor scars are very long, flabellate and extend almost to the
anterior margin.   They are bounded at the sides by the thickened
extension from the teeth but in front they are not deeply impressed.
They are divided by a median septum which almost reaches the
margin.   The diductor scar is elongate oval and posterior.

The dorsal valve is more regularly convex though flattened
medially with angular slope in all directions.   It is sinused on
the anterior margin.   The beak is blunt and the margins slope away
from it at a low angle.   On the interior the socket walls are stout
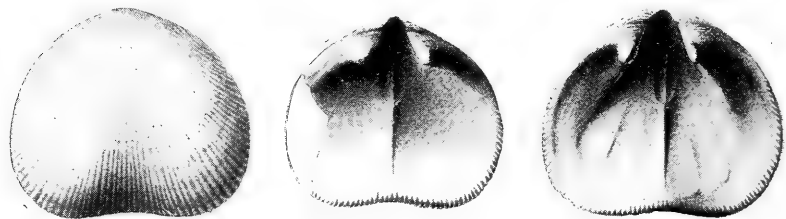
Rhipidomella lehuquetiana

and high, the sockets moderately deep and the cardinal process
rather feebly developed, being fused with the adjoining walls and
not projected beyond the hinge line; it is not divided.   The mus-
cular scars are posterior in a single or double subcircular pair
separated longitudinally by a broad low and short ridge.

Dimensions.   These shells measure in full growth about 15 mm
in width by 12 mm in length.

This peculiar little shell which is quite abundant, bears the char-
acters of senility as expressed in its thickened shell and shell pro-
cesses and the usual resorption of the beak by the delthyrium.   It
has the general characters of Rhipidomella modified to the expres-
sion presented by O r t h i s d u b i a of the St Louis limestone
[*see* Pal. N. Y. v. 8, pt 1, pl. 6A, fig. 18–22] which is a gerontic
form with such outline.

Lower Devonic.   Lehuquet's beach, Grande Grève, P. Q.

Rhipidomella hybridoides nov.

But for the extravagant size this shell attains at full growth it
would be quite impracticable to distinguish it from American forms

of Sowerby's well known Upper Siluric O r t h i s   h y b r i d a .
In its immature stages it is essentially that shell; at full growth

Rhipidomella hybridoides

its characters have changed by progression and indicate thereby a
Postsiluric age.

Lower Devonic.   Dalhousie, N. B.

Rhipidomella numus nov.

A shell directly comparable to R. (O r t h i s) o b l a t a Hall
of the Helderberg fauna, agreeing therewith in form and contour
of valves though perhaps never attaining the size of that species.
It differs therefrom: (1) in the slightly greater length of hinge,
but principally (2) in the very much coarser and sparser plication
of the surface. In R. o b l a t a the radial striae are fine and
crowded; in a typical example I find about 70 at a distance of 10

Rhipidomella numus

mm from the beak and at the anterior margin in a shell 32 mm
long, 190. In the largest example of R. n u m u s, 24 mm long,
there are 40 at 10 mm from the beak, 106 at the margin. Thus
there are practically two striae in R. o b l a t a to every one in
R. n u m u s; those of the latter angular, multiplying rapidly.
When compared with the rarer Helderberg species R. e m i n e n s,
its plication is still much coarser, its hinge not so long and it lacks
the elevated ventral beak of that shell.

The species is quite abundant.

Lower Devonic.   Dalhousie, N. B.

Rhipidomella musculosa Hall var. solaris nov.

These are all small shells with the enormous adductor scar in a state of high development. The shells are somewhat less circular,
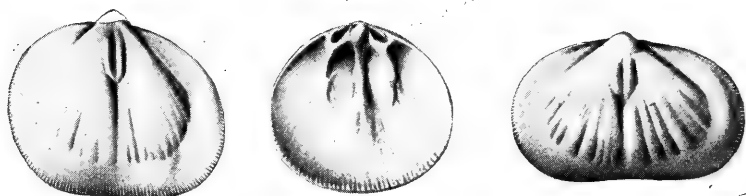
Rhipidomella musculosa var. solaris

more transverse than in the New York and Grande Grève Oriskany specimens of R. m u s c u l o s a, but their specific identity is not greatly veiled.

Lower Devonic. Moosehead lake, Baker Brook point; Brassua lake, east side; Moose river at Stony brook, Me.

Schizophoria? amii nov.

Shell of medium size, transversely subelliptical in outline. Ventral valve with slightly prominent beak which is not depressed but from the umbonal region departs a low median sinus which widens posteriorly and covers one third the width of the valve at the anterior margin. The dorsal valve is the more convex specially
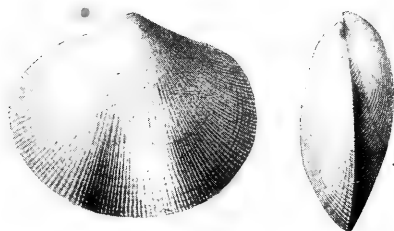
Schizophoria ? amii

in the median region which is elevated into a broad ridge corresponding to the concavity of the ventral. From this central ridge the sides slope somewhat abruptly and with a slight depression postlaterally. The surface is marked by fine angular radii very like those of D a l m a n e l l a l u c i a Billings (sp.) and are rapidly increased by implantation. Sometimes these striae are seen to end abruptly in elongate punctae as in some species of Rhipidomella (R. p e n e l-

o p e Hall, Hamilton). The surface is crossed by fine and obscure concentric lines. On the interior the ventral valve bears flabellate muscle scars but it is not known whether the scars of the dorsal valve conform to those of Schizophoria. Specimens of this species are easily confounded with those of D a l . l u c i a but the contour of the two is exactly reversed.

Dimensions. A normal specimen measures 18 mm in length and 20 mm in width.

Lower Devonic. Grande Grève, P. Q.

Orthostrophia canadensis nov.

Valves subcircular with a straight hinge; in contour the ventral valve is the shallower but bears a high median ridge, while the deeper dorsal valve carries a broad and low median sinus. Inside, the ventral valve has the muscular area concentrated pos-
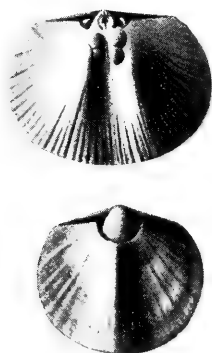
Orthostrophia canadensis

teriorly into a single scar not more extensive than the single pedicle scar in more typical orthids; the dorsal valve has a thin erect cardinal process and four distinct adductor scars.

The surface is marked by radial striae of unequal size.

Lower Devonic. St Alban beds. The Grande Cavée, and Cape Rosier Cove. This species is also known to occur in the Square Lake limestone of Northern Maine.

Dalmanella penouili nov.

This is a small circular shell without median depression or elevation but with an elevated ventral valve and high cardinal area, simulating in this regard a Schuchertella but without the deltidium

and having a short hinge line. The species is of the type of the
O r t h i s l e p i d u s Hall of the Hamilton shale fauna but is of
larger size than that little species is known to attain. The surface
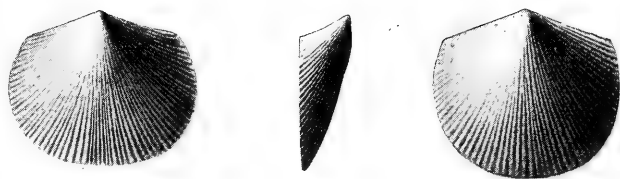
Dalmanella penouili

of the valves is finely striate, the elevated radial lines differing in
size, a few being considerably larger than the rest.

Dimensions. The average among several examples has a width
of 8 mm and length of 7 mm.

Middle Devonic. Gaspé Basin, P. Q.

Dalmanella drevermanni nov.

Cf. O r t h i s t e c t i f o r m i s Walther. Neues. Jahrb. für Min.
   Beil. bnd 17, 1903. p. 164, pl. 3, fig. 4 a-c
O r t h i s c i r c u l a r i s Sow. mut. p o s t u m a Frech. Lethaea
   Paleoz. 1897. v. 2, pl. 24 b, fig. 8. *nom. nud*
O r t h i s c i r c u l a r i s Sow. D'Archiac & deVerneuil. Trans. Geol.
   Soc. Lond. 1842. v. 6, pl. 38, fig. 12 *(non auctorum)*
O r t h i s s u b c a r i n a t a Hall Pal. N. Y. 3: 169, pl. 12, fig. 7-21

This shell, the only one of its type in the fauna, is essentially
a diminutive expression of O r t h i s s u b c a r i n a t a Hall of

Dalmanella drevermanni

the New Scotland beds. It has however affiliations with other
species, as cited above but the conditions of its occurrence oblige
us to regard the form as wholly mature; though with reference to
others its expression is immature. The exteriors of our shells
indicate fine and somewhat unequal striation, with rapid multipli-

cation of the sharp riblets, an almost flat dorsal valve with low broad median depression and a medially elevated ventral valve with broad not acute keel. It is closely similar to Orthis tectiformis Walther, as cited, from the upper Coblentzian of the Haiger.

Lower Devonic. Edmunds Hill, Chapman Plantation, Me.

Orbiculoidea montis nov.

Shell very large, brachial valve highly elevated, suberect, much longer on the posterior than on the anterior slope. Posterior curvature concave beneath the arched beak; in front of the beak the surface is convex, the shell being uniformly expanded in the
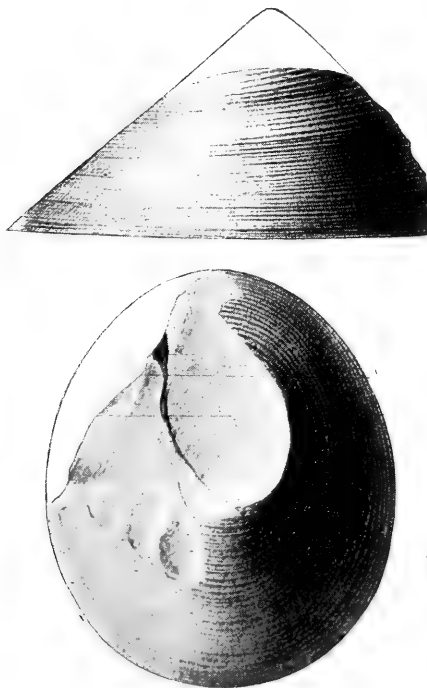
Orbiculoidea montis

pallial region. Marginal outline subcircular. Surface bearing fine distant elevated concentric striae which may undulate and inosculate. These are crossed by very fine radial lines which probably do not pertain to the epidermal layer.

The pedicle valve is concave exteriorly though the beak is elevated and the pedicle slit does not extend to the margin.

Dimensions. One brachial valve, virtually uncompressed, has a diameter of 57 mm and its original hight was about 35 mm. Another which has undergone compression apparently had a diameter of about 65 mm. A pedicle valve has a diameter of 45 mm.

Lower Devonic. Grande Grève and Percé rock, P. Q.

Lingula elliptica nov.

Shell of moderately large size, outline elongate and regularly elliptical, there being for the dorsal valve very little difference in the curvature of the umbonal and distal extremities, the latter being very slightly transverse, the former quite regularly curved. Sides direct, for a very short distance only partaking of the curvature of

Lingula elliptica

the rest of the outline. Surface low and evenly curved, margin bordered all the way round by a narrow flattened area; exterior marked by concentric lines of the usual style. On the interior of the dorsal valve is a long and low median ridge or septum, but in the ventral valve there is no such feature. Length 19 mm, width 10 mm.

Lower Devonic. Grande Grève and Percé rock, P. Q.

Glossina acer nov.

Shell of relatively large size, subtriangular, with acute and prominent beak from which the margins diverge rapidly for more than
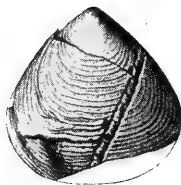
Glossina acer

two thirds the length of the shell, the distance across the pallial surface being four fifths the length of the shell. Anterior margin broad and nearly transverse. Surface covered by sharply elevated

and distant concentric lines which are mostly continuous though somewhat undulated but these frequently inosculate and become separated by narrower intervals toward the anterior margin. Length 17 mm, greatest diameter 13 mm.

This shell is like L. p e r l a t a Hall and L. s p a t i o s a Hall of the Helderbergian as the outline of those species has been represented but in this respect conjoined with the peculiar character of its surface markings, I am unfamiliar with any other species like it.

Lower Devonic.   Grande Grève, P. Q.

BRYOZOANS

Hederella blainvillii sp. nov.

This very interesting bryozoan incrusts the shells of L e p t o s -t r o p h i a   b l a i n v i l l i i Billings and, so far as our observation has extended, seems to attach itself always to the ventral or upper valve at an early stage in the life of the brachiopod and grow out-
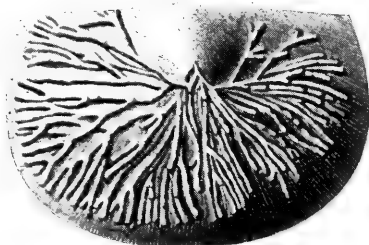
Hederella blainvillii

ward from the parent cell in all directions, keeping the apertures of the cells at or just a little distance above the margins of the shell. This habit evinces a true commensal condition not often shown in other cases of attached bryozoa; the water currents set up by the ciliated mantle of the brachiopod have helped to feed the members of the bryozoan colony, most of which stand in an attitude of readiness for this service.   This species occurs with extraordinary frequency on these brachiopod shells and seems to grow on no other save for an occasional simply branched stock on an upper valve of C h o n e t e s   h u d s o n i c u s .   H e d e r e l l a   r a m e a which I have described from the Oriskany of Becraft mountain, N. Y. elects attachment to L e p t o s t r o p h i a   o r i s k a n i a , always keeping its apertures toward the opening of the shell valves.   From

that species H. blainvillii differs in its much more rapidly branching zoarium and consequent shorter cells, producing a fuller and denser stock.

Middle Devonic.   Gaspé Basin, P. Q.

CORALS

Pleurodictyum lenticulare Hall var. laurentinum nov.

Pleurodictyum lenticulare is a species of the Helderbergian (New Scotland) fauna characterized by its very large and few cells, the walls of which are strongly marked by nodose and broken septa. A central cell, hexagonal in form, is bounded by six others and it often happens that the development of this spe-
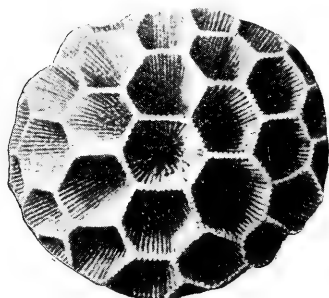
Pleurodictyum lenticulare var. laurentinum

cies does not pass this primitive expression. The form before us has the same form and size of cells which are marked by radial nodose and denticulated septa, these being most prominent and most irregular at the base. The lenticular corallum however grows to larger size, showing three cycles of cells about that which may be taken as central. In the measurements of the cells the New York and the Gaspé forms are alike.

Lower Devonic.   Grande Grève and Percé rock, P. Q.

GRAPTOLITES

Chaunograptus gracilis nov.

A shell of Leptostrophia magnifica Hall has affixed to it an irregularly branching black conchiolinous repent fossil which in structure and substance seems to be congeneric with the peculiar organism described and figured by Hall as Dendrograptus (Chaunograptus) novellus from the Waldron (Niagaran) fauna [Geol. Sur. Ind. 11th Rep't. 1881. p. 225, pl. 1, fig. 1, 2; before in Alb. Inst. Trans. 1879, v. 10, abstract, p. 2]. A com-

parison with the two types of this species in the State Museum,
shows that the Gaspé and Waldron forms are specifically different,
the Gaspé form being coarser and the apparent cells larger.   Since

Chaunograptus gracilis

no other form of this still problematic group of supposed repent
graptolites is known, the Gaspé form is apparently new.

Its characters are: Conchiolinous, delicate, frequently and ir-
regularly branching fronds, which are closely attached to foreign
bodies and consist of curved, commalike bottle-shaped cells or
branch segments, which are 1.4 mm long and .3 mm wide in their
distal part and bud in such a fashion from the preceding that the
branches become slightly zigzag-shaped.

Lower Devonic.   Grande Grève, P. Q.
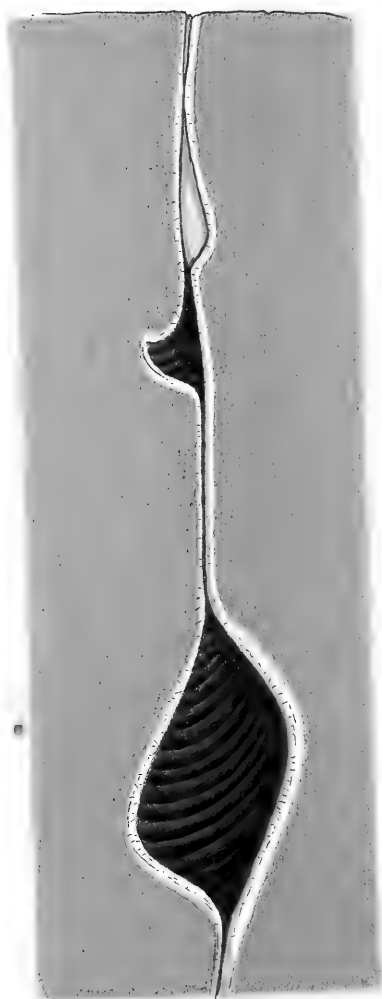
AN INTERESTING STYLE OF SAND-FILLED VEIN

BY

JOHN M. CLARKE

The margins of Port Daniel bay in eastern Quebec are fringed by vertical strata of Upper Siluric limestones rising in places to hights of several hundred feet. Over the eroded edges of these limestones are patchy deposits of the Bonaventure (Devono-Carbonic) sandstones and conglomerates, remnants of a sediment which has extensively sheeted this region.

At the east end of the bay, making the headland of Cap de l'Enfer, the limestones are of red and yellowish hues and are frequently seamed with vertical veins of inconsiderable size, these being parallel to, not transecting the dip. Many of these veins of quite irregular form resulting from an apparent deformation by solution and shearing of the original crack, have been but partially lined with deposition of calcite. The expanded portions of the fissures may be left wide open and empty but more often are filled by a regularly obliquely laminated deposit of dark red, compacted and cemented sand. An excellent illustration of these is shown here, the vein occurring in a yellowish limestone, the top being the eroded edge of the vertical stratum and the vein continuing down till it disappears in the water of the bay. The walls of this fissure are coated with a thin deposit of calcite uniformly laid on all surfaces, but nowhere meeting, while the cavities of the expanded portions of the fissure are filled with layers of red sand in curves concentric to the form which would result from deposition by gravity. It is entirely evident that this deposit of sand has infiltrated from the upper open mouth of the fissure, has sought and filled the lowest cavities first and it will be noticed has also filled the passage connecting the two lower cavities while the upper cavity and the passage leading to it still remain open ready to receive additional deposits. This red sand is very sharply laminated and well compacted. Its color and composition leave little doubt that it has been derived from the Bonaventure conglomerates during the period of their erosion and that this erosion was accomplished before the fissure was wholly filled. There is no longer

any possibility of completing this process for now the nearest out-crop of the red conglomerates and sandstones is some rods away and below the level of these fissures.

This purely mechanical filling of a fissure is in its process unlike many of the recorded examples of sand veins and dikes where the filling has resulted from normal deposition of sand on an eroded and fissured surface. The writer has described the case of the Oriskany sand penetrating to fissures in the underlying Siluric rocks at Buffalo, N. Y. Many parallel and far more striking cases of similar character are known and have been described by va-rious writers, Diller, Cross, Geikie, Pavlow, but the case here de-scribed differs from these in the evident filling of the fissure, not at the time of deposition of the overlying sandstone deposit, but at the time of its erosion, through the action of a small infiltering surface current. This conclusion is fairly established by the vacant upper cavities of the fissure indicating an entire removal of the supply of material before the filling of the cavity was complete.

THE EURYPTERUS SHALES OF THE SHAWANGUNK
MOUNTAINS IN EASTERN NEW YORK

BY

JOHN M. CLARKE

In the recent efforts to correlate the stratigraphy of the Paleozoic rocks of eastern New York with the more lucid succession in the central and western portions of the State, the present viewpoint indicates some unsettling of long recognized values which have been ascribed to the formational units of the former.

In eastern New York we have to deal with paleogeographic conditions which were doubtless diverse from those further west in the old open Paleozoic gulf and until the recognition of the difference in these conditions no trustworthy correlation could be approximated.

Briefly summarized for our present purpose, these old physiographic differences are evinced first by the existence of an isolated tongue of late Siluric and early Devonic deposits beginning at Skunnemunk mountain in Orange county and running southwestward into New Jersey, the Skunnemunk basin as it has been termed by Ulrich and Schuchert. For this area which has been carefully studied by several geologists we must employ the term basin with reserve as it is an area of very steep dips, at the north separated from the more western band of the same formations by a broad area of the " Hudson River " (Lorraine, Utica and Trenton) shales, and at the south by the crystallines and intrusives of the protaxis. There are many excellent reasons to regard this area as the eastward branch of a broadened anticline whose decapitation has exposed both the Lower Siluric beds and the crystallines, and its actual present outcrops may eventually be shown to merge toward the north in the vicinity of Kingston with the parallel western band of contemporaneous deposits. This is a point requiring more refined investigation. The other factor in this divergence of physical conditions is the fairly demonstrated existence in the early Paleozoic of a rising barrier at the head of the Appalachian gulf, occupying the present site of the Helderberg mountain and forcing deposition at as early a period as the late

Siluric around the southern margin of this barrier, hence excluding these in large measure from the outcrops now exposed along the northern and eastern edges of the Helderberg escarpment.

The key to the recognition of these physiographic differences east and west was found first in the stratigraphic value of the formation in eastern New York termed by the early geologists the " Coralline limestone " and accepted by them and their successors as such eastern representative of the Upper Siluric Niagara or Lockport dolomitic limestone of western New York. We term this formation at the present time, or such part of it as was called by Hall, who described its fossils, Coralline limestone, the *Cobleskill dolomite*.

The very refined study of this formation made by C. A. Hartnagel and published in these reports has shown not only the continuity of this unit across the State from west (Buffalo) to east, interrupted from Schoharie to Rondout or along the north edge of the Helderberg, but also demonstrated its position at the top of the Salina formation, hence of far later age than the Niagaran. With this well determined fact in hand this formation, heretofore used as a bench mark for the assignment of the formations in eastern New York above and below it, again serves a similar purpose and necessarily involves important modifications in correlation. Following the clues herein suggested, Mr Hartnagel has recently given attention to the stratigraphic value of the Shawangunk grit which constitutes as a heavy sheet of arenaceous deposits all except the basal parts of the Shawangunk mountains in Ulster county and extends south through western Orange county into New Jersey.

This extensive series of arenaceous deposits has been, from the earliest classification of the formations, uniformly interpreted as of the age of the Oneida conglomerate of central New York, but Hartnagel's researches indicate with probability that in its typical localities this Oneida conglomerate is a local phase of Medina sedimentation and lies within the recognized upper limits of that formation. In the Skunnemunk region the Shawangunk grit is separated from the Cobleskill limestone by a series of formations of upper Salina age which in their extension from Ulster county to New Jersey vary considerably in thickness, lithologic character and fossil contents.

The details of these later correlations are published in Mr Hartnagel's article appearing in another part of this bulletin. The

prime inference that concerns us in this place is that the Shawangunk grit so far from being an eastern representative of the Oneida conglomerate of early Upper Siluric age is actually the arenaceous representative of the Salina period in eastern New York. Hartnagel's investigation of this problem is based wholly on stratigraphic evidence; the paleontology of the formations involved was not taken into account and indeed there was not at the time any paleontologic evidence to be considered so far as the Shawangunk grit is concerned for no fossil had ever been seen in it.

We here present a noteworthy corroboration from novel and extremely interesting paleontologic evidence of this correlation originally made upon purely stratigraphic data.

In typical sections of the Salina series of formations in western New York, the peculiar arid conditions of this epoch are accompanied and indicated by the appearance of a profuse and remarkable crustacean fauna presented by the Pittsford shales and described by the writer in New York State Paleontologist Report, 1900, pages 83 and 92, and C. J. Sarle in New York State Paleontologist Report, 1902, page 1080.

Although it has been possible to exploit these shales in only one locality, in and along the Erie canal near Pittsford, Monroe co., the fauna which has been described covers the merostomes Eurypterus, Pterygotus, the new genus Hughmilleria, Pseudoniscus and the phyllocarids Emmelezoe and Ceratiocaris.

The black shale with this fauna graduates by alternation into the thin waterlimes above and it is not until the lapse of the entire sedimentation of the Salina, which at its climax involved extreme salt pan conditions, that the merostome fauna comes back in the final stage of the period with the breaking down of barriers and the freshening of the waters. This later phase is the period of the Bertie waterlime with a rich and widely known fauna of Eurypterus, Pterygotus, Dolichopterus, Eusarcus, Pseudoniscus, Ceratiocaris etc.

During the past season, my assistant Dr Ruedemann, having occasion to visit Otisville, in western Orange county, to examine some graptolite-bearing layers of the " Hudson River " shale to which my attention had been courteously directed by Dr H. B. Kümmel, visited a quarry in the Shawangunk grit alongside the Erie Railroad at that place and there observed a black shale layer

in the grit, from which he obtained a few very evident segments
of Eurypteruslike merostomes.

The discovery of such fossils in eastern New York, long looked
for but never before found, and their evident importance in the
correlation of the sediments, rendered it desirable that these beds
should be extensively exploited.

This work of collecting has been carried out successfully by
Mr H. C. Wardell and the material on which the following account
of the stratigraphy of the fossils is based is quite extensive.

The present line of the Erie Railroad from Otisville west for a
distance of a mile or two passes over the steep grade of the
Shawangunk mountain. Extensive operations are now under way
to reduce this grade by a tunnel directly through the mountain.
The present railroad cut at the summit of the hill transects inclined
layers of the Shawangunk grit and above this cut at the east lies
the long quarry face from which the crustacean remains were
first obtained. This rock face has been torn into extensively in
the removal of rock which is crushed and used for ballast.

The stratigraphy along this section is as follows: About
¼ mile west of Otisville along the railroad are " Hudson River "
shales standing at an inclination of about 45° w. Westward the
eroded edges of these shales are abruptly overlain by the con-
glomerate basal layers of the Shawangunk grit series, the Green
Pond conglomerate of Darton and the New Jersey geologists,
which in the expansion of the formation in the Kittatinny mountain
attains a much greater thickness than here. In the railroad cut
these conglomerate layers attain a thickness of about 50 feet but
pass gradually into the finer typical grit above. The thickness that
may be ascribed to the grit here is 450 feet and it again passes
upward into looser sandstones.

One half mile south of this section along the Erie Railroad the
beds referable to the Shawangunk series attain a thickness of
approximately 550 feet. From the base of the series at the con-
tact with the Lorraine shales through a section 350 feet are
innumerable thin layers of black shale. Above this the thin shale
layers become gray and more argillaceous but continue to carry
the merostome fauna with the addition of some singular phyllo-
carids whose structure has not yet been completely made out.

Mr Wardell has measured this section in detail and the full
statement of it is very interesting as showing the remarkable con-
tinuation of these alternations of black shale bands through the
arenaceous deposits.

Plate A

Unconformity between basal conglomerate layers of Shawangunk grit and the "Hudson River shale." The latter contains fossils of Utica age. Erie Railroad cut just west of Otisville

Section of the Shawangunk series in ascending order

Erie Railroad cut ⅓ mile west of Otisville

129 ft of " Hudson River " shale with interbedded thin layers of sandstone

Unconformity

SHAWANGUNK SERIES

12' conglomerate
2" shale
8' conglomerate
2" shale
1' conglomerate
2" shale
16' 8" conglomerate
2" shale
6' 10" grit
6" shale
2' 10" grit
6" shale, thinning out rapidly
13' 5" grit
2" shale
5' grit
4" shale
7' grit
1' shale becoming thicker at top of cut
41' grit
50' (estimated) of grit not exposed between top of railroad cut
      section and base of quarry section

Erie Railroad quarry ⅓ mile west of Otisville

101' grit
5" shale
3' 6" grit
2" shale
2' grit
2" shale
7' 6" grit
2" shale
12' grit
8" shale
3' grit
10" shale
17' 2" grit

4" *shale*
6" grit
1" *shale*
4" grit
2" *shale* Productive band. From a vertical section of 23' 6"
3' 8" grit beginning 198' 7" above contact of Shawangunk
2" *shale* grit and " Hudson River " shale
7' grit
2" *shale*
11' grit
1" *shale*
2' 2" grit
2" *shale*
1' 2" grit
2" *shale*
8' grit
5" *shale*
9' grit
2" *shale*
4' grit
10" *shale*
3' grit
1" *shale*
8' grit
1' *shale*
21' grit
4" *shale*
8' grit
2" *shale*
1' 9" grit
2" *shale*
1' 6" grit
3" *shale*
5' grit
2" *shale*
6' grit
4" *shale* Very productive band in section 16' 8" beginning at
10' grit 298' 5" above contact
2" *shale*
22' grit
2" *shale*
6' grit
3" *shale*
1' 6" grit Productive band; section of 1' 9", 343' 3" above
2" *shale* contact
10' grit
3" *shale*
7' grit
4" *shale*
60' grit (estimated) with occasional very thin layers of shale. As
   these 60' have not been quarried shale layers have been
   weathered away at exposures.
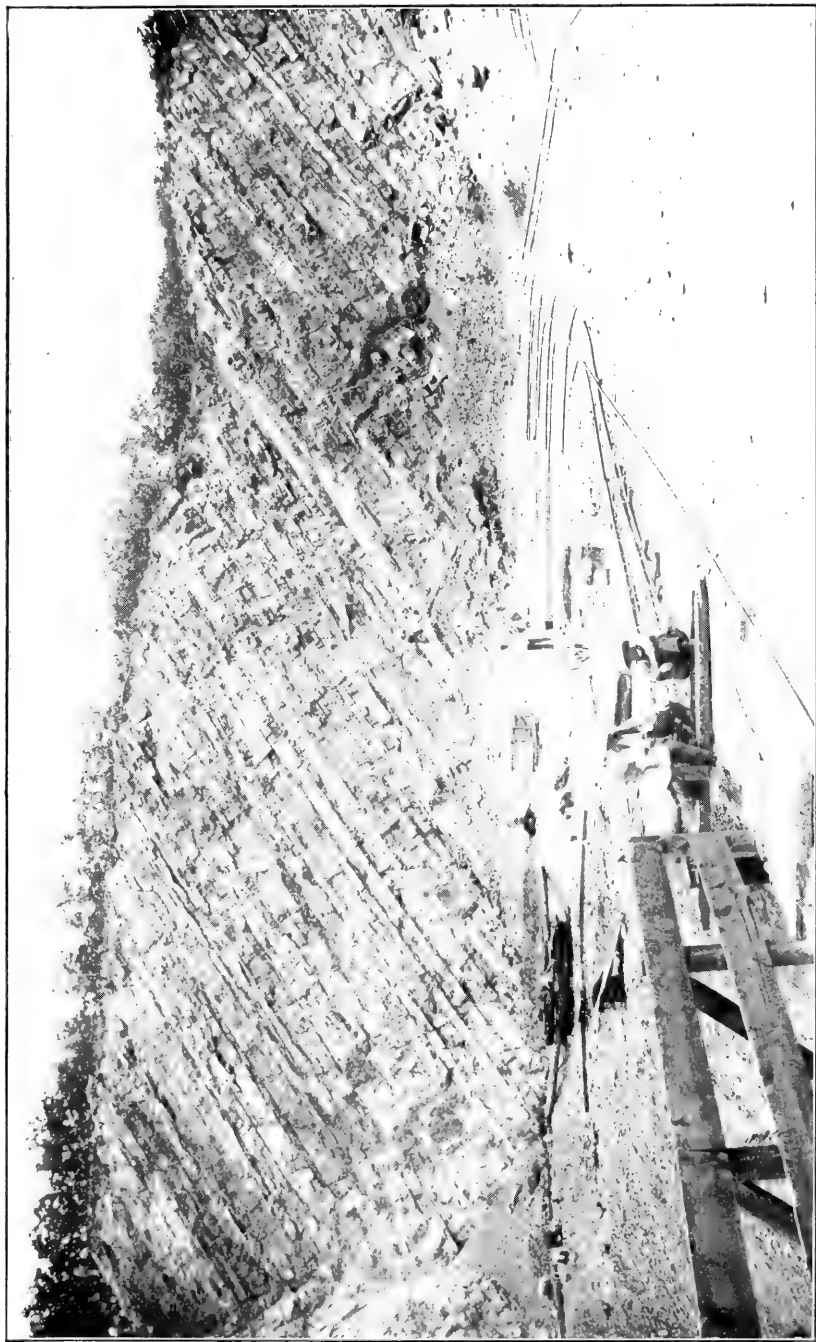
Quarry in Shawangunk grit, Shawangunk mountain, ½ mile west of Otisville.   The black shales are intercalated at frequent intervals and in discontinuous patches among the grit layers.

It is these shale bands indicated by italics that contain the crusta-
cean remains.   No one of them exceeds a few inches in thickness
and while it is not to be said that every layer has afforded fossils, yet
it is to be expected that each may.   The most productive layers have
thus far proved to occur in groups as indicated on the section.
These shale layers are not often continuous along the bedding either
for the entire strike or dip of the section but they thin and pinch out,
reappear and continue for a short distance to again vanish; in other
words they occur in a multitude of originally horizontal patches
over the surfaces of the sand layers.   This section therefore is but
a statement of variation in sediment along a given horizontal;
above or below the succession would probably vary in some meas-
ure.   The shales carry no other fossils than the crustaceans or at
least none have yet been found and the sands have afforded nothing
in the way of fossils except a few bodies resembling in some
respects A r t h r o p h y c u s   h a r l a n i   Hall (A. a l l e g a n i -
e n s i s   Harlan) which the weight of evidence brought forward
by the recent investigations of these problematical bodies by C. J.
Sarle indicates to be a worm burrow.

The preservation of the crustacean remains in the black shale
is peculiar and in some respects unusually favorable for the study
of the smaller organisms of the fauna.   The parts are altered to
a shining coaly film usually incrusted by a tenuous layer of pyrite
which when moistened brings out details of structure not other-
wise to be ascertained.   Indications are at hand of an extensive
and commanding crustacean fauna.   Great masses of mangled and
dismembered parts indicate how extraordinarily abundant these
Eurypterids have been, but entire individuals are great rarities.
The carapaces, segments and limbs afforded smooth flat surfaces
which have invited the process of shearing and this has usually
glazed the bodies and often destroyed the half of their surfaces.
Young forms, probably because of their size and compactness,
seem to have more often escaped dismemberment while larger ones
are represented by only an occasional fragment of striking size.
Heads, especially of young animals, are common but even these
broad shields in larger animals have been too thin to resist the
shearing pressure upon them.   The range in size of the animals
here present is worthy of especial note.   We have entire animals
ranging from 2.5 mm to 5 mm in length, by far the smallest and
youngest Eurypterids yet recorded and exceedingly interesting for
the ontogenetic evidence they afford; and there are body segments
which indicate creatures of great size—that is a probable length of

several feet, proportions hardly exceeded in Beecher's well known restoration of the Catskill S t y l o n u r u s e x c e l s i o r and only surpassed by a great, but little known Pterygotus from the Bertie waterlimes in Herkimer county.

In the descriptive account of these fossils, we have indicated an affinity with the fauna of the Pittsford shales of western New York which is emphasized by the character of the deposit in which they are involved. It is entirely safe to say that the fauna carries sufficient evidence of an historic stage earlier than the predominant Eurypterus fauna of the Bertie or final stage of the Salina.

The evidence to be drawn from the Arthrophycuslike fossil from this grit as indication of approximation in age to the Medina formation of western New York is entirely negligible as its significance is not material as an index fossil.

The presence of this crustacean fauna in the Shawangunk deposits thus may be taken as conclusive of the Salina age of the entire series of conglomerates and sandstones. This inference, if substantially grounded, brings us to an enlarged and modified conception of the coastal physiography during the phases of the Salina period.

The Shawangunk mountains and their extension into the Kittatinny range of New Jersey lie on the eastern boundary of the Appalachian gulf and their sediments while depositing were embraced in it.

Referring again to the normal Salina succession in western New York, we recognize the introductory, culminant and decadent stages of the Salina sea representing respectively the gradual shoaling of the shore waters with the formation of bars, brackish lagoons and salt pools, the complete abscission of the waters within the barriers forming a salt lake of saturated brine in which no organism has left a trace, and finally the breaking down of the barriers and restoration of normal marine conditions.

No such consecutive conditions present themselves at the eastern boundary of the gulf during this period. Here rapid deposition was in continuous progress with no further evidence of seclusion from the main gulf waters than is afforded by the presence of these black shale layers and their fauna. We have had occasion elsewhere in discussing the bathymetric value of bituminous shales, to bring forward the very strong evidence for their formation at great depths, arguments abundantly supported by the writings of others, but it is probably needless to state that certain dark shales not necessarily bituminous carry accessory evidence of deposition

in shallow water. Our present knowledge of the habits of the merostome crustaceans derived both from the living and fossil forms, indicates the shallow water or barachois origin of all sediments in which these remains abound. In the Shawangunk section we have a fauna constantly repeating itself through a thickness of 650 feet which elsewhere appears only and briefly at the base of the Salina series.

While it may seem hazardous to infer that this section represents only the early part of the Salina stage, yet the section of these rocks afforded by the Nearpass quarry at Port Jervis shows that above the Shawangunk grit are the red Longwood shale, Poxino Island shale, Bossardville limestone and the Decker Ferry limestone. All these are below the layer now correlated with the Cobleskill horizon of central and western New York. At Poxino island, Dr Kümmel estimates the thickness of the red shale at 2305 feet. We have then in southeastern New York and northern New Jersey a very great thickness of deposits which now seem to be the equivalent of the Salina shales and dolomites of central and western New York and though in the latter region it has been found practicable to subdivide the Salina deposits into a series of minor stratigraphic units, the total thickness of them all is very much less than one half, probably considerably less than one third of the thickness of the deposits which we may ascribe to the same stratigraphic interval in the region under discussion.

The continuity of this crustacean fauna indicates uninterrupted communication through the secluded waters of this period. Were it not for the presence of the fauna at the east one might entertain the conception of a torrential origin for the heavy mantle of Shawangunk grit. This might be in entire harmony with the prevalent arid condition of the time, but the innumerable repetitions of this fauna preclude this idea. This arenaceous deposit, we have noted, belongs to a portion of the gulf set off from that further west by the protrusion of the Helderberg shoal or peninsula, an eastern bay receiving a rapid terrestrial drainage with resultant deltiform deposition of low gradient, from an elevated but distant source. The intrusion of these terrestrial waters at the east prevented highly saline conditions.

Description of the fauna

In attempting to portray the character of this interesting association of merostomes I am obliged to recur to the statements already made in regard to the preservation of the bodies. Cir-

cumstances have permitted the retention of the smaller parts,
chiefly very young entire individuals or head shields of immature
forms, but have almost wholly destroyed larger bodies or left merely
patches and fragments of them. Thus this attempt encounters two
serious obstacles which may constitute two distinct sources of error:
(1) the effort to ascribe to very imperfectly known mature animals
a variant series of young stages; (2) the recognition of the char-
acter of mature adults and representatives of large genera from the
parts which have by accident escaped total destruction from shearing
and compression. Added to both of these difficulties is the consid-
eration that the appendages of all forms have rarely been observed.
A very determined effort has been made to overcome these defects
by the acquisition of copious material. The fossils are not abund-
ant. It has required the handling of a great many tons of rock
to acquire the half ton or so of specimens from which the selection
has been made for this descriptive account. The future will com-
plete our knowledge of the fauna; for the immediate present we may
content ourselves with the remarkable evidence it affords of the
age of the Shawangunk grit and of ontogenetic variations hitherto
unrecognized in this group of animals.

MEROSTOMATA

Order EURYPTERIDA

Family EURYPTERIDAE

Genus EURYPTERUS

The typical adult Eurypterus carries 12 tergites or dorsal seg-
ments and a telson. On the ventral side the number of segments
or sternites is reduced by one by the fusion of the first two into the
genital operculum. There have been few exceptions recorded to
this numerical value of the segmentation and it is generally recog-
nized as standing for the proper expression of complete segmenta-
tion in the entire family. It is interesting to note that the earliest
well known Eurypterid, S t r a b o p s   t h a c h e r i   Beecher,
described from a large entire specimen from the Cambric of Mis-
souri, carries but 11 segments.[1] This would be a phylogenetic
condition entirely compatible with the ontogenetic expressions pre-
sented by the material now before us, wherein we have very young
phases of Eurypterus with 11 and an extremely early stage of
Hughmilleria with apparently but 10 segments.

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[1]Beecher, C. E. Discovery of Eurypterid Remains in the Cambrian of Missouri. Am. Jour.
Sci. 1901. 12:364.

The addition of segments with growth may be regarded as a normal procedure in these Eurypterids as it is known to be in Limulus. and the trilobites. Other ontogenetic variations will be referred to under the accounts to be given of the various species recognized.

Eurypterus maria nov.

Plate 1, figures 1–4; plate 2, figures 1–7; plate 3, figures 1–7

The general form of the largest observed individuals of this species [pl. 1, fig. 3; pl. 2, fig. 2] is elongate and slender with very little abdominal expansion and no lobation of the segments. In these ephebic conditions the head is somewhat elongate, regularly rounded in front and with subparallel lateral margins. The eyes are crescentic, subcentral, as far asunder as the inner margin of each is from the margin of the shield.

The ocellar lobe is well defined at an early stage. A specimen 63 mm long without the telson, apparently mature, has 11 segments, but a break across the body leaves room enough for a 12th. The width of the base of the head is 15 mm and this is but very slightly less than the greatest expansion of the abdomen. Little trace of surface sculpture is visible on any of the parts.

Immature phases. The smallest individual that can be referred to the species has an actual length of 5 mm [pl. 2, fig. 1] and possesses seven relatively broad segments tapering without expansion backwards. Although this specimen is not complete, at the extremity it has tapered so rapidly that there is little place for anything additional but the telson. Only suggestions of structural features are to be seen on the head. On plate 1, figure 1, is a more complete animal, 5.5 mm in length with 11 segments and the telson. Here again are only suggestions of structure on the head, but very noteworthy is the marked contraction of the postabdomen bringing out strongly the scorpioid abdomen which now seems indicative of a nepionic condition both in ontogeny and phylogeny. Probably certain well known large merostomes like E u r y p t e r u s s c o r-p i o i d e s and species of Eusarcus in which this abdominal expansion is pronounced at maturity, are to be interpreted as arrested in respect to such development. In the chapter on the Merostomata in Zittel-Eastman's *Textbook of Paleontology* I introduced figures. of immature examples of E u r y p t e r u s r e m i p e s [p. 676, fig. 1420, 1421], the smallest individuals of any Eurypterid known at that time, wherein this abdominal contraction and expansion is strongly pronounced and in the smaller of the two there is also a very marked paucity of abdominal segments. This abdominal con-

traction in E. m a r i a is not long retained. Plate 1, figure 2 shows an entire specimen with a full supply of segments and with relatively broader abdomen than in the mature form but its outline gradually rounds to the more slender posterior segments. The length of this specimen is 8 mm. In the incomplete individual shown in figure 4 of the same plate all the essential features of maturity appear to have been assumed, even the eyes and ocelli having their normal development. This fragment represents an animal probably 10-11 mm in length.

The variability of the eyes in size and position in these young phases invites special attention. We have figured on plates 2 and 3 a considerable number of these head shields and it will be observed on consulting these figures and their accompanying natural size outlines that while there is no direct relation between the size of the head and the size and position of the eyes the instability of these features loses itself on the approach to adult size. Accompanying these changes there is an equally irregular variation in the outline of the head which from being short and almost semilunar gradually approximates the more elongate form of the ephebic type [pl. 2, fig. 2].

We may therefore summarize the ontogenetic changes derivable from the evidence which this species presents as follows: (1) Very early change from the scorpioid to the gently tapering abdomen; (2) gradual but irregular increase in segmentation; (3) gradual but irregular elongation of the head; (4) highly irregular variation in position of the eyes, but gradual travel from the margins inward to their normal locus.

Eurypterus myops nov.

Plate 6, figures 1–5, 6 (?)

This species is in many respects a diminutive expression of E u r y p t e r u s p i t t s f o r d e n s i s Sarle, the head (all that is now known of it) being subquadrate, almost as much squared in front as behind, the eyes large, semicircular, subcentral and approximate and the ocellar mound developed in mature forms. The material is insufficient to establish any marked variations in growth, as the species is among the less common forms of the fauna. One example shown in figure 6, which is doubtfully referred to the species has the eyes large and almost marginal. There is a striking similarity between this species and the last of the Eurypterid race, the Eurypterus described by de Lima from the Permian of Bussaco, Portugal.

Eurypterus ? cicerops nov.

Plate 5, figure 10

This diminutive head shield is remarkable for the extraordinary development of the compound eye lobes which are anterior and very prominent and though the shield has a diameter of only 4.5 mm, the ocellar mound is fully developed. So unusual is the aspect of this specimen that it can not be assigned to any of the other species here noted, and though entirely immature, it is given a distinctive designation.

Eurypterus ? cestrotus nov.

Plate 3, figures 8–10

Of this species we have only enough to satisfactorily establish its difference from other forms—the two specimens here illustrated. Both show the peculiarly ornamented frontal border of the cephalon which carries a row of denticulations. One of these specimens conveys a satisfactory idea of the form of the body, and presents the ventral aspect but there is some uncertainty in regard to the number of segments and though evidences of four pairs of legs are present the structure of these is not apparent. The head shown in figure 10 indicates that the compound eyes are large and very far forward. It is entirely probable that when this species becomes better known it will have to be excluded from the genus Eurypterus.

Genus HUGHMILLERIA

This genus was established by C. J. Sarle[1] on specimens obtained from the Eurypterus-bearing Pittsford shales lying at the base of the Salina group in Monroe county, New York.

Hughmilleria has been represented heretofore only by the type species H. s o c i a l i s, and its var. r o b u s t a. The critical structural difference between this genus and its close allies Eurypterus and Pterygotus is the existence of chelate preoral appendages, much larger than in Eurypterus (E. f i s c h e r i Eichwald) very much shorter and smaller than in Pterygotus, but with the marginal eyes of the latter genus. The form of the animal is slender and terete with no marked abdominal contraction while the head has an elongate rounded subtriangular outline which is quite characteristic. The species here assigned to the genus Hughmilleria has been so treated on the basis of its form and the shape and structure of the head; the chelate appendages have not been found and

[1]A new Eurypterid Fauna from the Base of the Salina of Western New York. N. Y. State Paleontol. Rep't 1902, 1903. p.1080.

in the absence of these there must be some reservation made, subject to future demonstration or correction.

Hughmilleria shawangunk nov.

Plate 4, figures 1-4; plate 5, figures 1-9

  With the same form of head and outline of body as in H. s o c i a l i s this species combines a diminutive size, the average being well shown in figures 1 and 3 of plate 4. The full equipment of abdominal segments (12 and telson) is possessed at this adult stage.

Exceedingly instructive but of the same tenor as evidence already given are the developmental stages. On plate 4, figure 2 is represented under great enlargement from a camera drawing an entire individual 2.5 mm in actual length, the smallest known of the fossil merostomes. This is in no sense a nauplius and we are entirely without evidence of any such stage in these crustaceans. It is however an emphatic expression of the differences between the nepionic condition and the adult, showing the short, broadly triangular head, the expanded abdomen which under the best illumination appears to carry but five segments and the abruptly contracted postabdomen with five narrow and deep segments. Thus again in this very early growth stage is the scorpioid outline sharply defined. On consulting the figures of various head shields of different sizes shown on plate 5, it will be seen that there is not much variation in the position of the eyes. In some instances the eyes are not discernible [fig. 5, 6] and it is quite possible that in these they may be still entirely submarginal.

Genus PTERYGOTUS

Pterygotus ? otisius nov.

Plate 6, figure 7

An elongate subquadrate head with eyes anterior, far apart and just within the margins; ocellar mound well back between the posterior horns of the eye crescents; surface quite smooth. The specimen figured and one other of similar character are all that is known of this species.

Genus STYLONURUS

Stylonurus ? sp.

Plate 6, figures 9 (?), 10 (?), 11, 12; plate 7, figures 1–5; plate 8, figures 9, 11 (?)

Everywhere through these dark shales are fragments of large crustaceans most of which are so distorted as to no longer show the outline of the parts though they exhibit distinctive surface

characters. Occasionally a large segment is recognizable, and the figures cited show such parts as are more or less definitely determinable. Thus we have the terminal joints of a long cylindrical appendage [pl. 7, fig. 1] which evidently represents the long fifth leg in Stylonurus. Figure 12, plate 6 and figure 9, plate 8 are also long, slender leg joints which probably pertain to small individuals of the same genus. Some of the abdominal segments are noteworthy for their lobation, a large one is shown in figure 11, plate 6 and smaller ones of the same type in figures 9 and 10 of the same plate. The largest of these has been so subjected to lateral compression by shearing that the left moiety has been distorted beyond recognition, while the same pressure has developed the lobar depression at the right into a distinct break or suture. Such lobed segments are rare in all Eurypterids but are especially noteworthy in a species which has been described by Fr. Schmidt as S t y l o n u r u s ? s i m o n s o n i from the Upper Siluric of Rotziküll, Oesel.[1] The principal specimen on which this species is based consists of a part of the underside of the head with the opercular plates and 6 to 7 abdominal segments. In all these the dorsal furrows are sharply defined and divide the segments into a convex, broad median part and flat lateral portions which can not be regarded as having any relation to the so called "epimera" of Pterygotus. It is true that in typical expressions of Stylonurus such as S. l o g a n i Woodward, and S. e x c e l s i o r Hall there is no evidence of such lobation of the abdomen and though Schmidt has found with these abdominal parts the long leg joints just as we have similar parts associated in the Shawangunk shale there is very excellent reason for the presumption that we are here dealing with creatures which when more fully known will prove to be generically distinct from Stylonurus. The great size attained by some of these bodies in the Shawangunk shale is notable, and in contrast with the rather diminutive series of forms we have been dealing with. Some of the creatures must have attained a length of 3 to 4 feet, but per contra, this would be a small size for Stylonurus, the large forms of which have been shown by Woodward and by Beecher to have reached a length of 7 to 8 feet.

Phyllocarida

Plate 6, figure 13; plate 8, figures 12, 13, also 14–21 (?)

Two very different species of Phyllocarids are indicated by the caudal parts as shown on plate 8, figures 12 and 13, one having

[1]Bul. de l'Acad. Imp. des Sciences de St Petersburg. 1903. 5 ser. 20:199.

a slender telson spine with longer, slender and apparently curved cercopods, the other with a heavy telson much longer than the cercopods which are short bladelike and longitudinally striated. These are both from the black shales of the grit and neither can be more exactly determined generically than by the term Ceratiocaris. In the gray shales above the grit have been found a number of fragments of bodies no one of which gives any clue to its exact outline save that they are sometimes rounded at one extremity and all are ornately engraved by longitudinal anastomosing lines or groups of continuous or broken lines as illustrated on plate 8, figures 14 to 21. I think there is no reasonable doubt that these are carapaces and parts of segments of Phyllocarids, but if so, of a type of structure heretofore unknown. Future investigations will, it is hoped, elucidate the nature of these peculiar bodies.

In the Pittsford shales there are Phyllocarids which I have described under the names C e r a t i o c a r i s   p r e c e d e n s and E m m e l e z o e   d e c o r a and it is usual to find these crustaceans associated with the merostomes in all the Upper Siluric occurrences of the latter.

EXPLANATION OF PLATES

PLATE 1

Eurypterus maria nov.

See plates 2 and 3

1 An entire individual 5.5 mm in length. This specimen presents
   11 segments and telson, so far as it has been possible to
   determine them. On the left side the abdominal contraction
   is emphasized, in some measure perhaps by distortion. On
   the carapace the size and position of the eye spots as repre-
   sented is somewhat presumptive in view of the character of
   the preservation.

2 Another individual entire except for a part of the telson and
   having an actual length of 8 mm. Here the postabdominal
   contraction is slight, the total number of segments 12, the
   eyes apparently almost marginal although this position is
   again uncertain, and traces of legs are seen.

3 An incomplete specimen 20 mm in actual length. This pre-
   sents in part the ventral aspect of the animal, showing the
   position of the metastoma in place, one swimming foot and
   segments.

4 A specimen with an actual length of 8 mm, head and seven
   segments. The head shows fully developed subcentral eyes
   and central tubercle bearing the ocelli.

G. S. Barkentin, del.
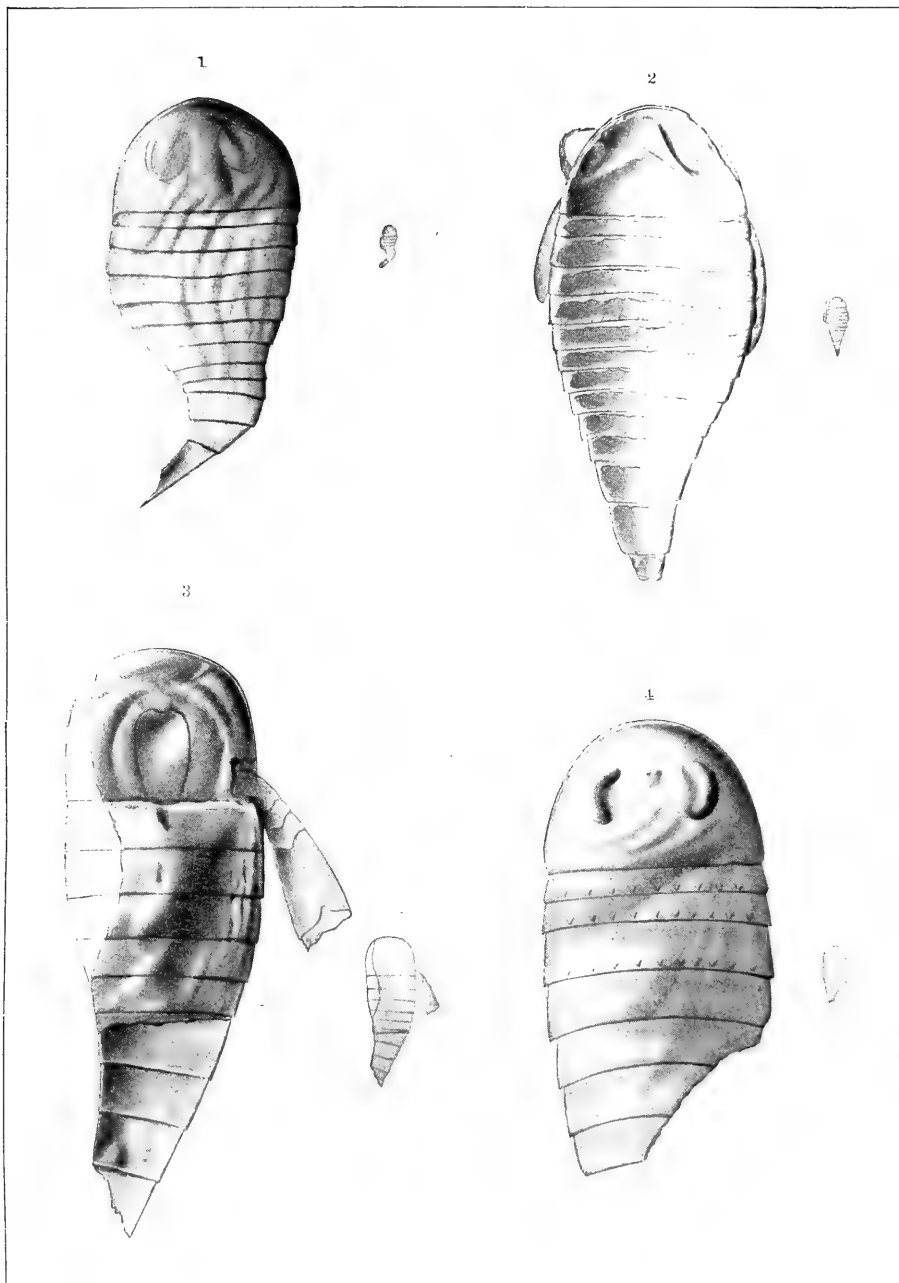
PLATE 2

Eurypterus maria nov.

1 A specimen 5 mm in length, with head and seven segments.

2 This individual is the most nearly entire of any example of this species observed which approaches the features of maturity. It carries head and at least 11 segments and the slender form of the body at this stage is specially noteworthy. The actual length of the specimen is 63 mm.

3 A head with neck segment attached and with eyes very close to the antelateral margin. The natural size outline in this and the following figures is at the right.

4-7 Head shields of various immature phases with eyes well developed but still holding an anterior and intramarginal position.
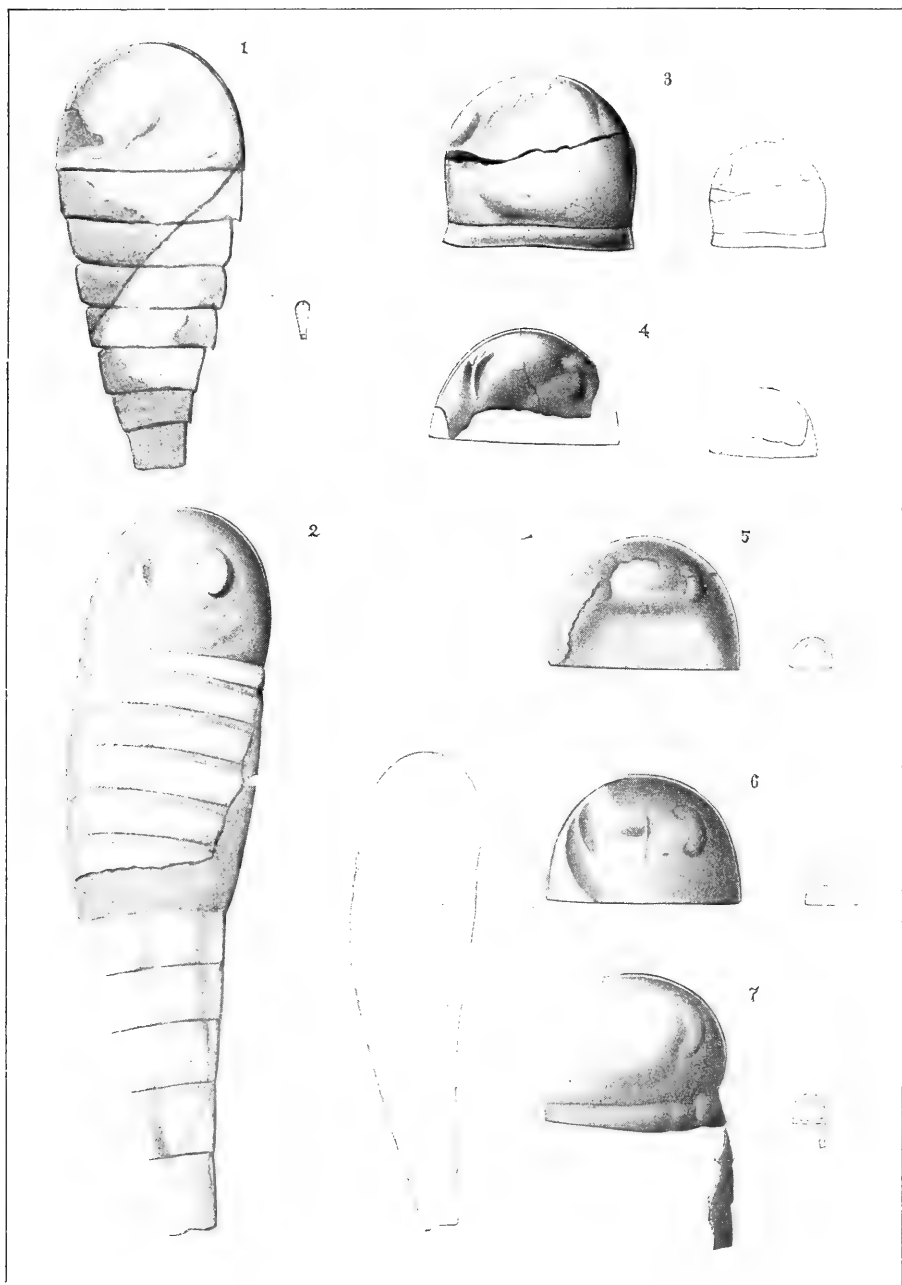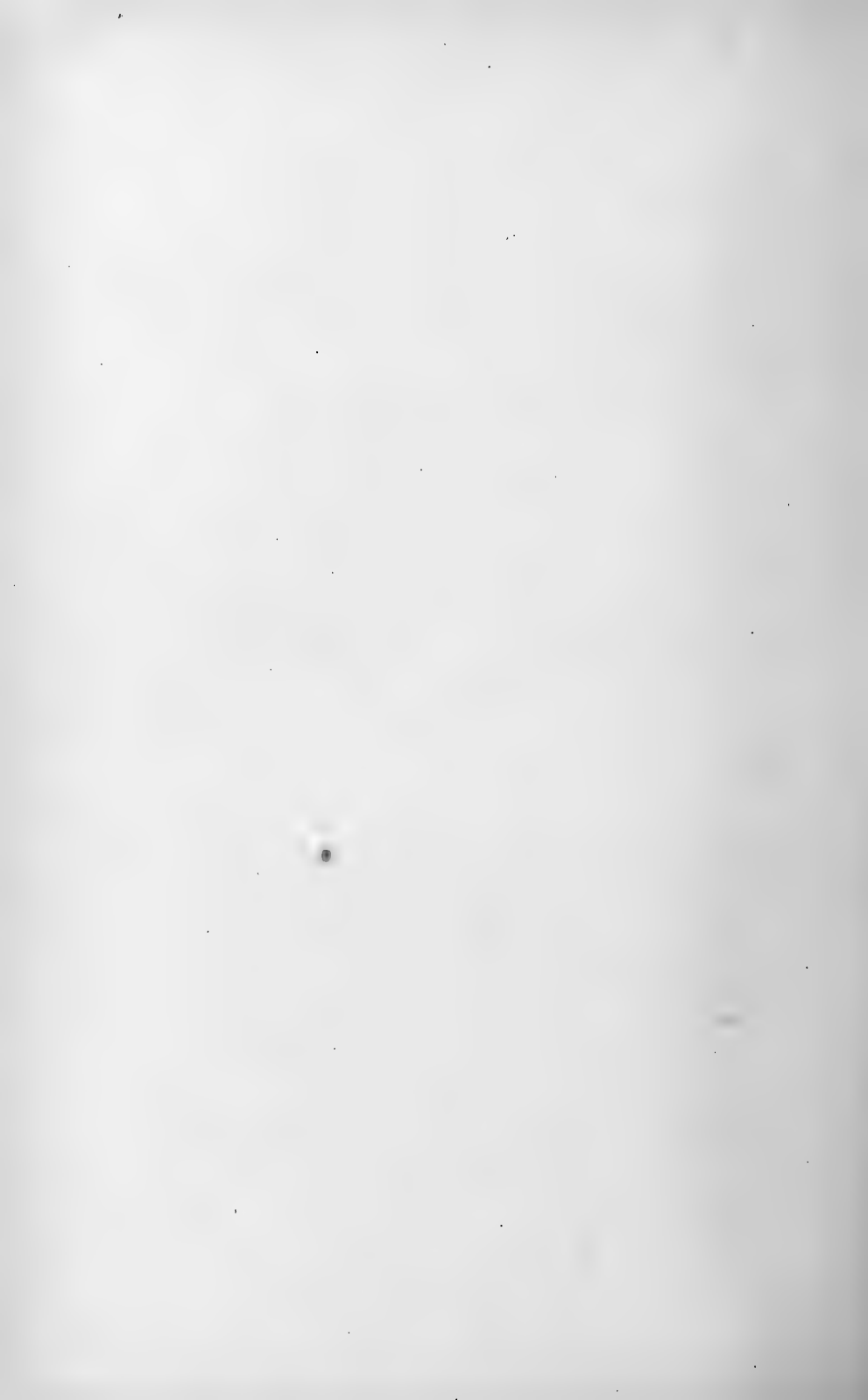
PLATE 3

Eurypterus maria nov.

See plates 1 and 2

1-7   A series of the heads showing notable variation in the position and size of the eyes.   All are immature phases and the variation of these features seems to have but little direct relation to the size of the animal.   In figure 3, the eyes are apparently absent.

Eurypterus ? cestrotus nov.

8   An individual, natural size, so crushed as to obscure the distinction of the cephalic parts but indicating the general form of the animal and its segmentation.   In figure 9 is given an enlargement of the peculiar denticulate anterior cephalic margin.

10   A head with portions of segments of a young individual, showing the same denticulate margin.   The eyes seem to be large and far forward and the whole expression of the head is such as to convey the belief that the animal pertains to a genus as yet undefined.

G. S. Barkentin, del.
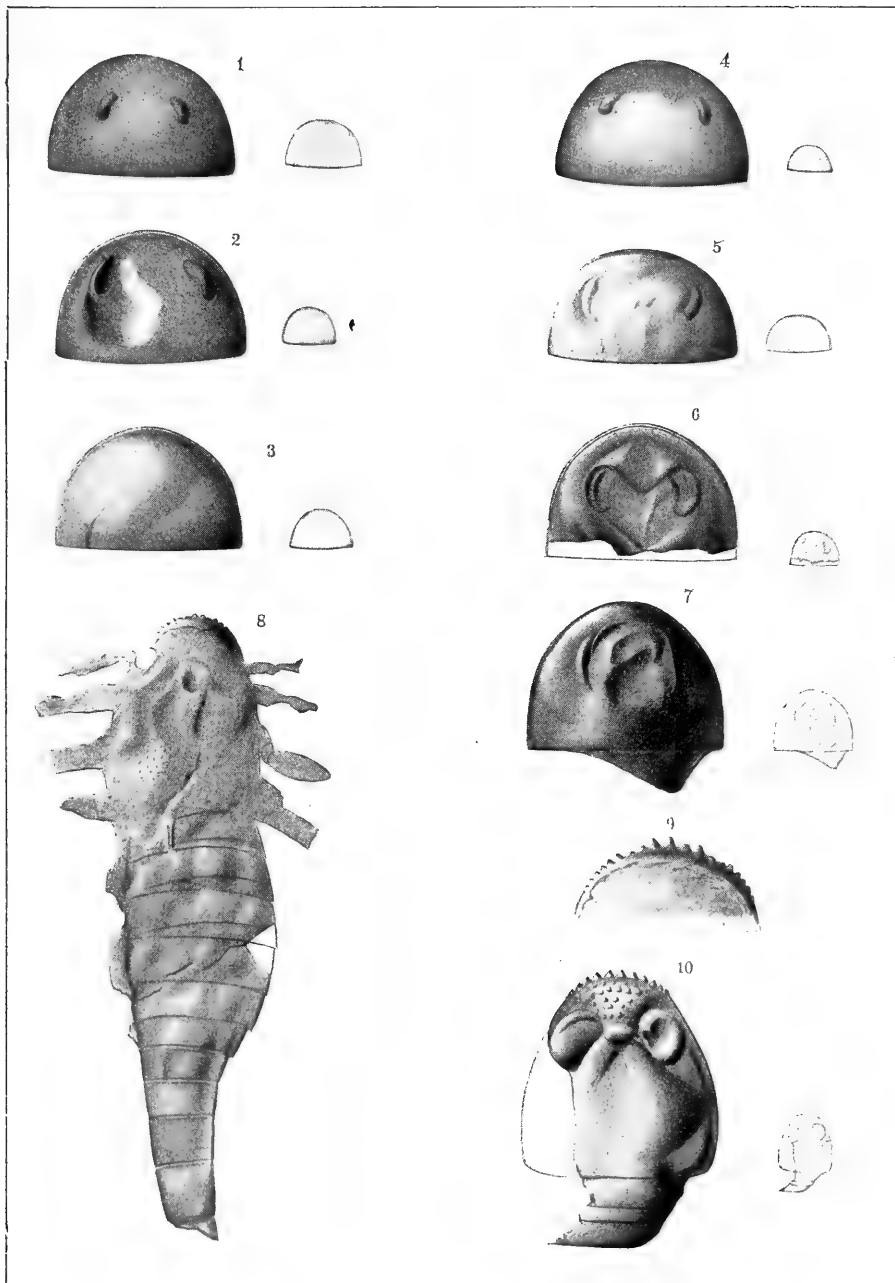
PLATE 4

Hughmilleria shawangunk

1   An average mature example with 12 segments and telson and
    one crawling leg. This specimen shows the approximation
    in form of body, shape of head and position of eyes to
    H. s o c i a l i s .

2   The smallest entire individual yet observed and regarded as
    pertaining to this species. This specimen has an entire
    length of 2.5 mm, its head is short, broadly subtriangular
    and the eyes can not be located. Especially notable is the
    broad scorpioid abdomen emphasized by the contraction of
    the postabdomen. So far as it is possible to determine, the
    abdomen carries not more than five segments, the post-
    abdomen the same number, more clearly defined.

3   A nearly entire individual with an actual length of 40 mm,
    retaining portions of the appendages. The number of seg-
    ments is represented as 10 but it is not certain that some may
    not be lost by overlap.

4   A head and two segments; showing eyes and ocelli.
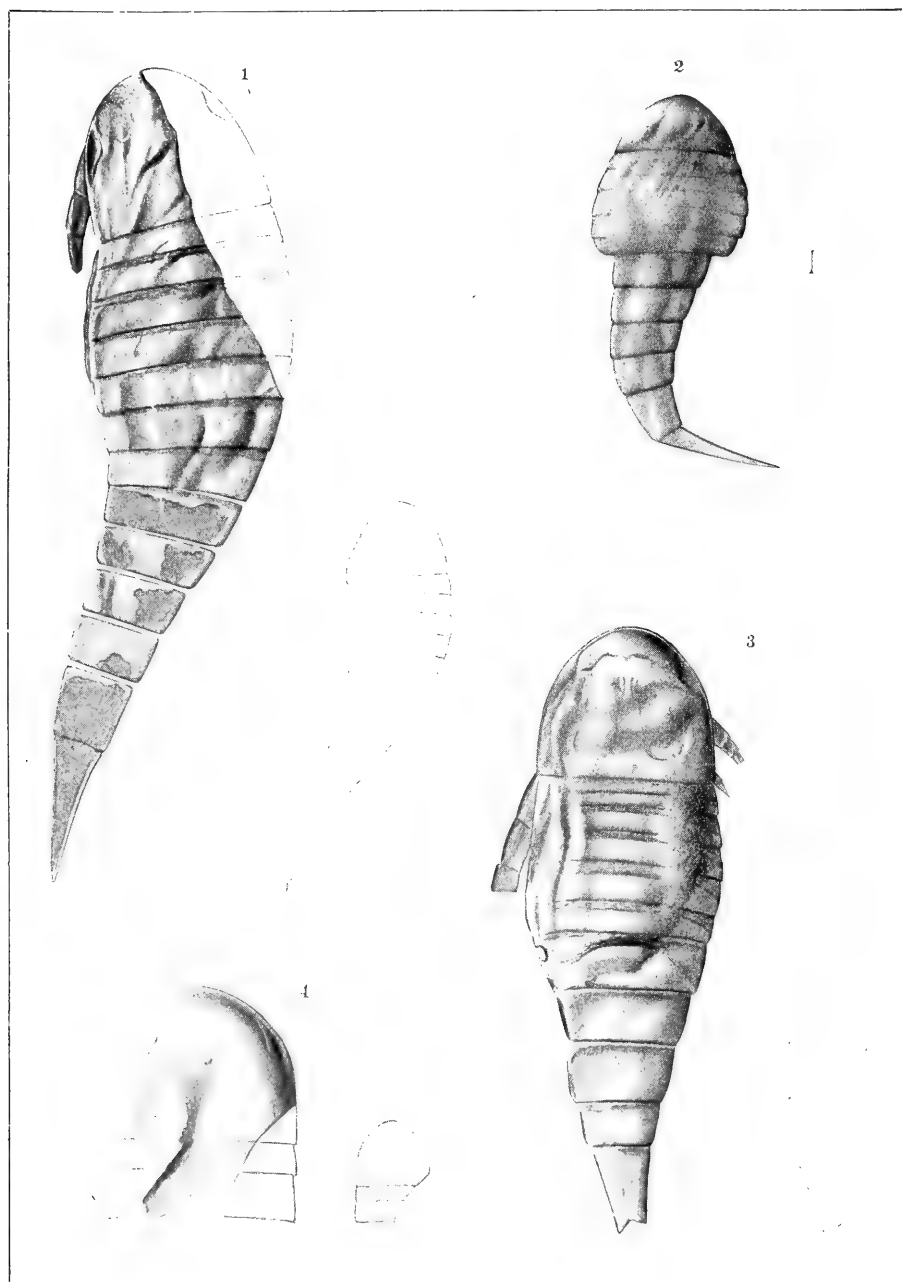
PLATE 5

Hughmilleria shawangunk nov.

1-9 Head shields having for the most part the subtriangular elongate outline and marginal eyes characterizing the species H. s o c i a l i s . In these details there is however some variation; in the very small heads represented by figures 3, 5 and 8, all trace of eyes is practically wanting. It is quite probable that the minute head shown in figure 9 with its large intramarginal anterior eyes and ocellar mound represents the following species. Actual variations in position of the compound eyes in this species are apparently from submarginal and marginal to intramarginal.

Eurypterus ? cicerops nov.

10 This singular head shield has the lobes of the compound eyes small, circular, greatly elevated and anterior with a definite development of the ocellar mound. The body is regarded as a young stage of a species whose adult form is not yet recognized.

G. S. Barkentin, del.
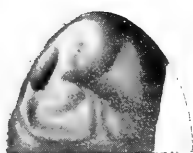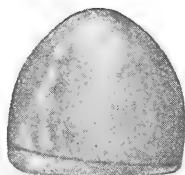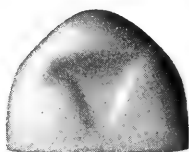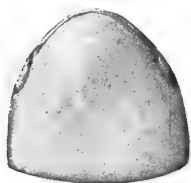
PLATE 6

Eurypterus myops nov.

1-5 Heads of this species, showing the quadrangular form and some slight variation in the position of the large approximate eyes. Figures 3-5 are natural size.

Figure 6 may possibly belong to this species, and represent a young phase with the eyes well toward the margin.

Pterygotus ? otisius nov.

7 A quite distinct form of head with anterior almost marginal eyes, ocellar mound and smooth surface.

Eurypterus or Pterygotus

8 Eye of a large specimen.

Stylonurus ? sp.

9-11 All these segments show a lobation which seldom occurs in the Eurypterids but is best exemplified in the species of Stylonurus described by Fr. Schmidt [see p. 309]. The large segment in figure 11 indicates how a slight lateral shearing has developed this lobation into a sharp division line (suture?) at the right, while from the same line of weakness at the left the whole lateral moiety of the segment has been completely distorted.

12 Two long slender leg joints.

Phyllocarida

13 The middle spine or telson of a phyllocarid.
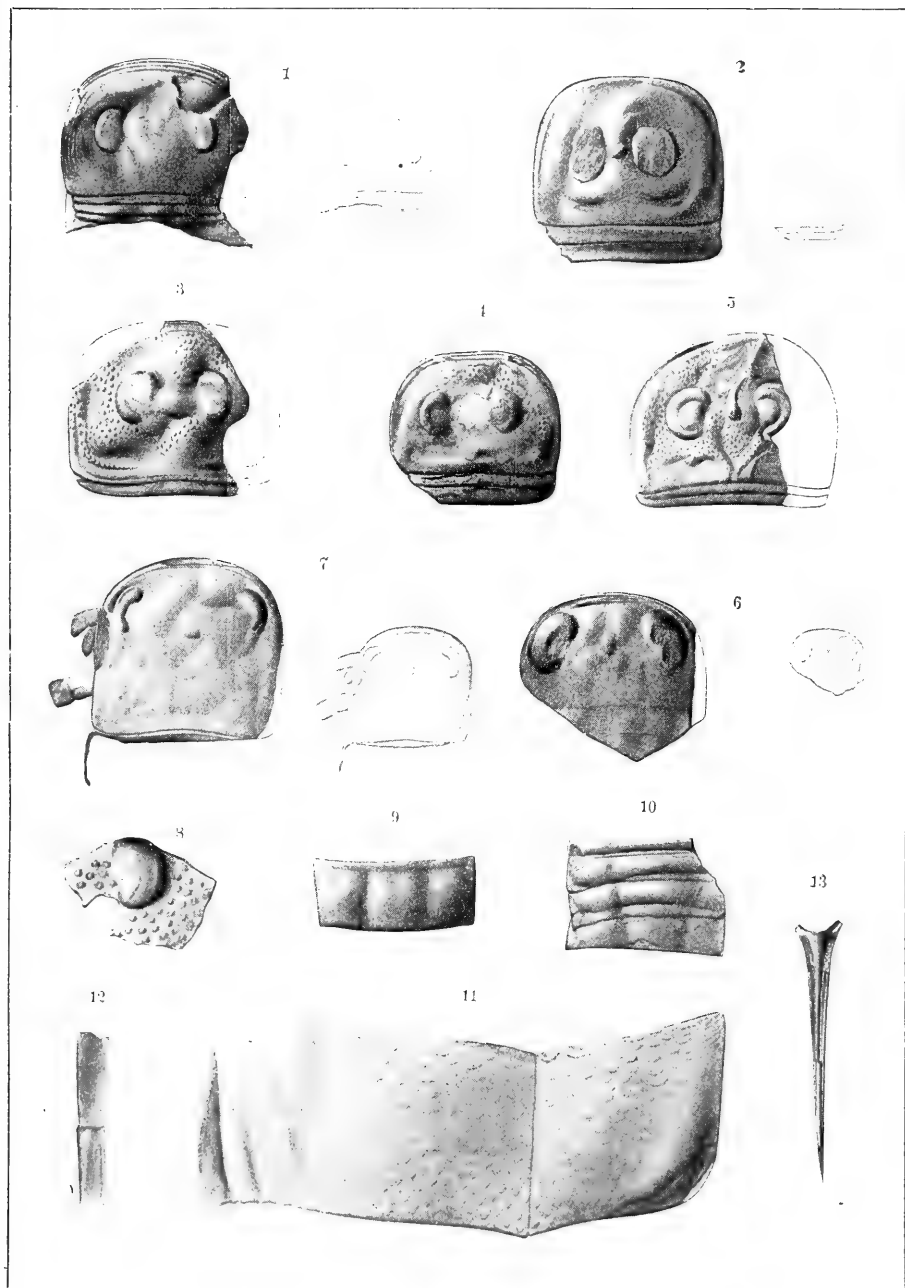
G. S. Barkentin, del.

PLATE 7

Stylonurus sp.

1   The terminal joints of the long posterior or fifth foot.

2-5 These are parts of segments or shields which will convey an idea of the dimensions attained by some of these merostomes. All have been more or less distorted by shearing but such fragments are common in the shales and indicate the abundant presence of these large animals in the fauna. They all may be regarded as belonging to the genus Stylonurus.
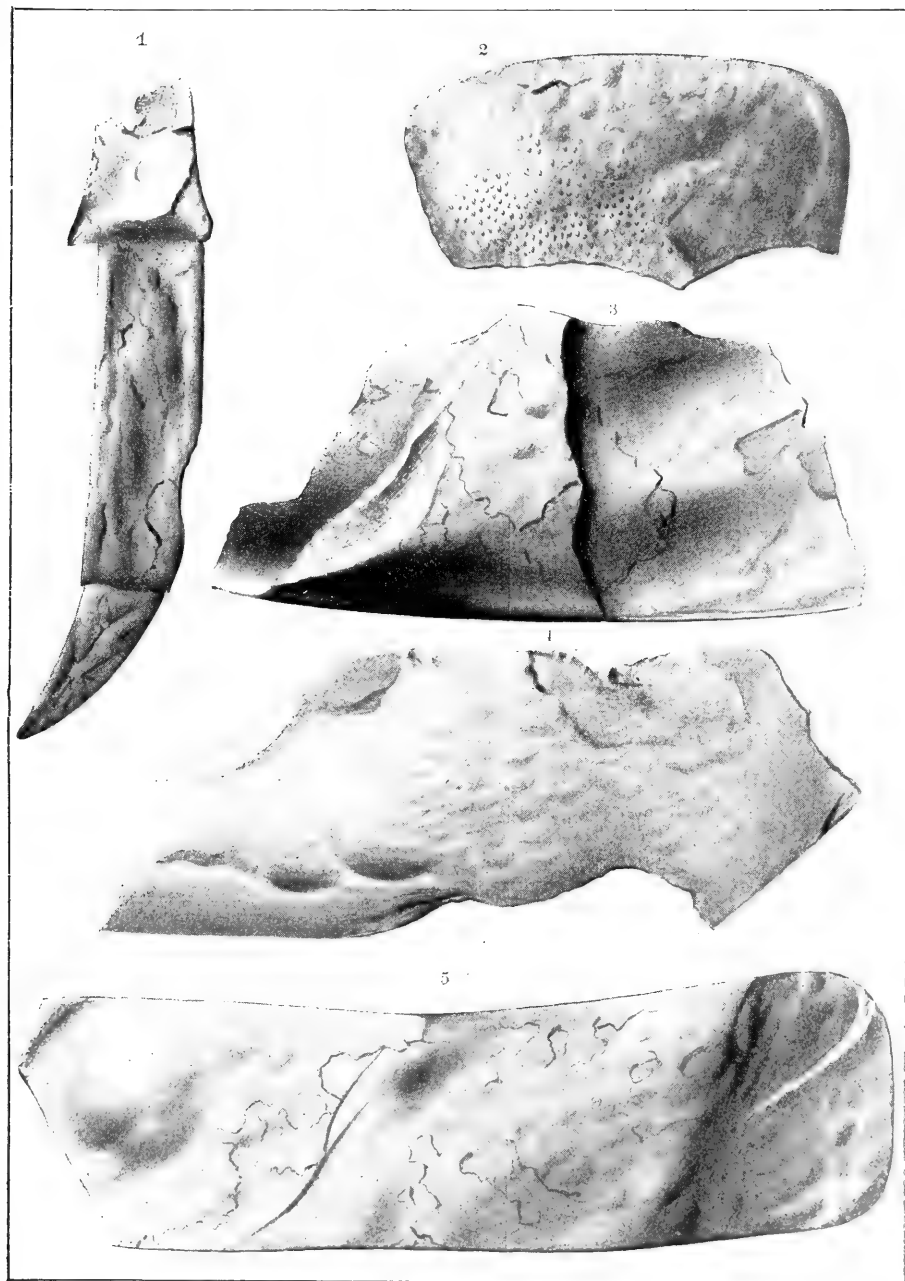
G. S. Barkentin, del.

PLATE 8

<div align="center">

Segments and joints

of **Eurypterus, Hughmilleria**, etc.

</div>

1-8 These are all natural size drawings and 1-4, 7 appear to be sternites, the transverse suture being clearly marked in all. Figure 2 is a second sternite and bears the mark of the opercular appendage. Figure 6 is a series of abdominal tergites; 8 the half of a sternite (second?) with very unusual surface markings.

9 Two joints of a slender grooved appendage (Stylonurus) with denticulated ridges.

10 Gnathobase of a swimming foot.

11 The filamentous terminal joints of one (or two) large endognathites, probably of Stylonurus.

<div align="center">

Phyllocarida

Page 309

See plate 6

</div>

12 Telson and cercopod. x2

13 The same parts of a very distinct species with heavy and long central spine with short lineate cercopods.

14-21 A series of fragments which afford no definite clew to the original form of the bodies, but the enlargements accompanying each show the very peculiar character of the surface engraving. There is no reason for assuming any association between these bodies and the tail spines already referred to, but it is fairly certain that they can with entire safety be regarded as Phyllocarid remains. They have been found only in the gray shale beds lying at the top of the grit and black shale series.
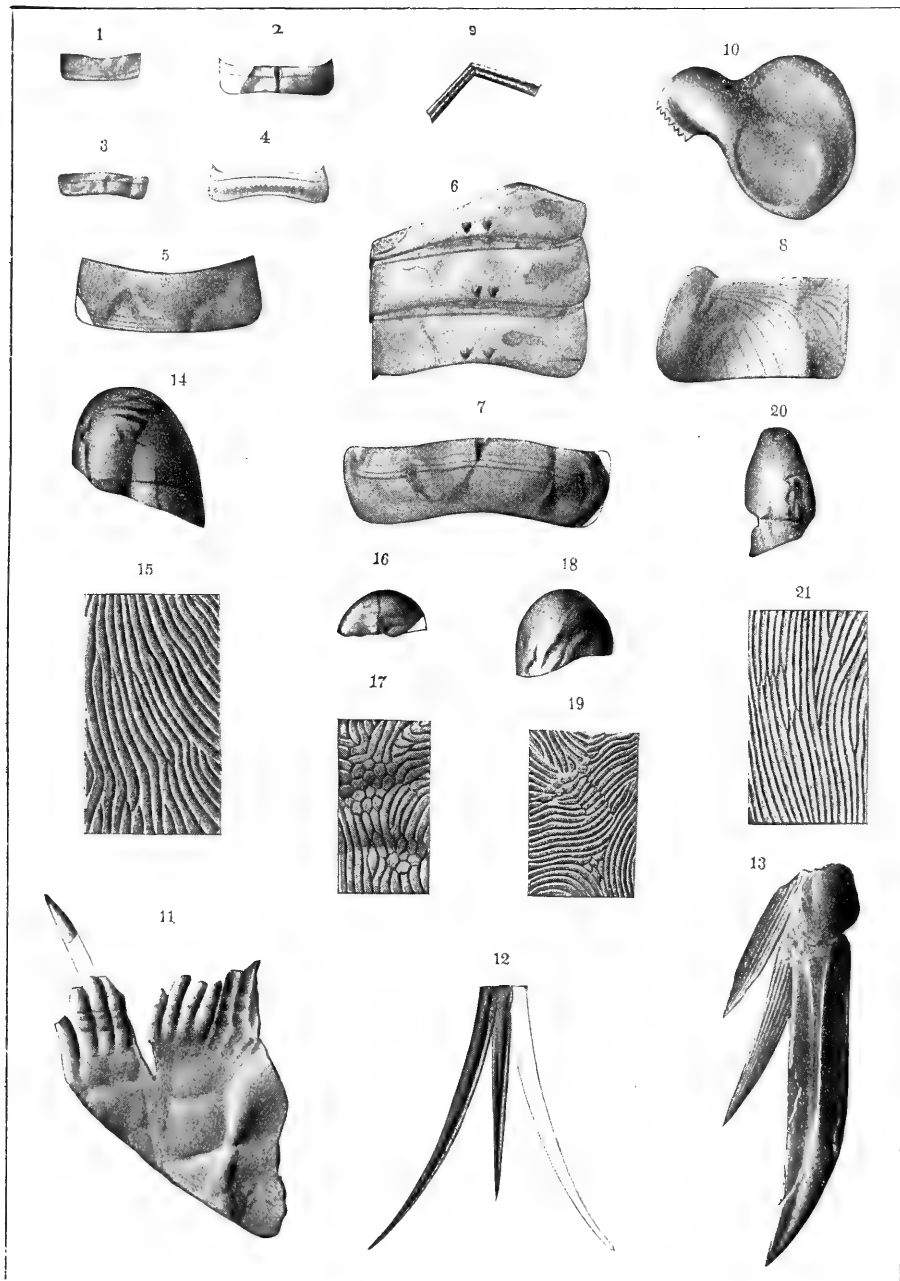
G. S. Barkentin, del.
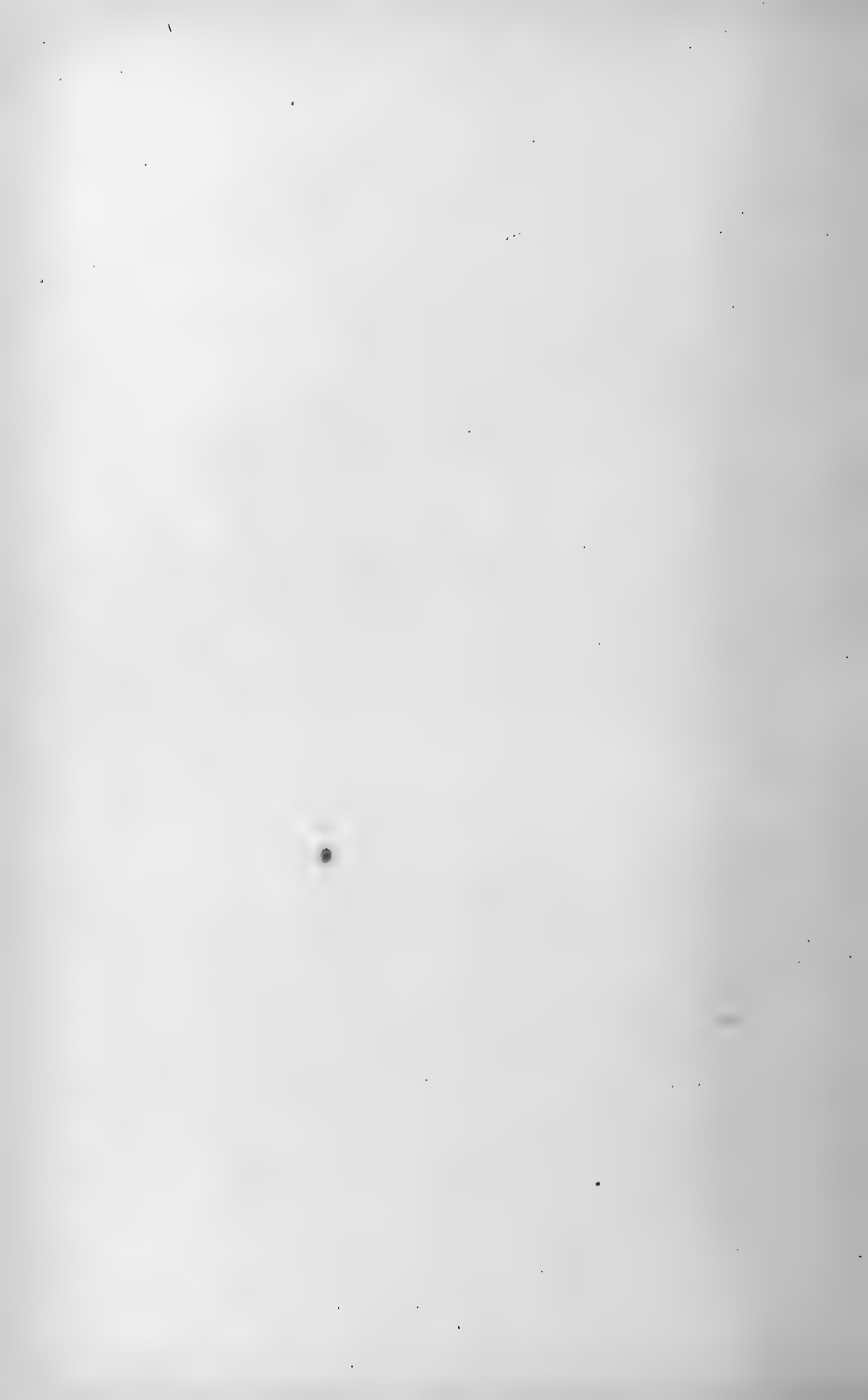
View of the Grimes gully, Naples, N. Y., showing the locality (X—X) of the tree here described

A REMARKABLE FOSSIL TREE TRUNK

FROM THE MIDDLE DEVONIC OF NEW YORK

BY

DAVID WHITE

The fossil trunk which forms the subject of this description lies on a large slab mounted in the eastern bow window of the Geological Hall of the New York State Museum. The specimen, which is over 3.25 meters in length, is extraordinary not only for its perfection, but also for the fact that it represents, so far as I am aware, by far the largest tree of its order yet found in Precarbonic rocks. But it is still more remarkable for the new light which it throws on the habit of growth, superficial features, and systematic affinities of one of the early forerunners of two great Paleozoic plant groups, the Lepidodendreae and the Sigillariae. It will be seen that its interest and importance as illustrating a stage in the development of the Paleozoic Lepidophytes (Lycopodiales) far overshadows its great value as a unique and most imposing specimen of a very ancient type of tree.

Source and age of the specimen

The specimen was discovered in 1882 by D. D. Luther, in the upper Devonic shale at the mouth of Grimes gully, about 1 mile west of Naples, N. Y. The shale has been described[1] as the " Hatch shale." It comprises the topmost division of the Portage group in that meridian of the State. The disentombment of the remains of the tree was completed under Dr J. M. Clarke's direction some years later, and a short announcement of its installation in the State Museum was published[2] in 1887.

As originally quarried the specimen is reported to have been about 5 meters in length to the point of outcrop in the side of the ravine. No evidence of branching was seen, and the branches, of which there probably were but few, were lost by the erosion of the shales during the cutting of the ravine. At the point of outcrop exposure the trunk is said to have been but 70 millimeters in width. At the time of mounting in the Museum during the absence of

[1]N. Y. State Mus. Bul. 63. 1904. p.33.
[2]Clarke, J. M. Science 225. 9: 516.

Mr Clarke the tree was unfortunately reduced to its present length to suit the dimensions of the embrasure at the side of the building. The fossil remains consist of the nearly completely flattened impression of the trunk, on a portion of which the carbonized cortex still lies. The matrix is a very fine grained blue shale.

The specimen is so important on account of the varying cortical features, some of which suggest most interesting relations to several groups of the upper Paleozoic Lepidophytes, as to merit description in more than usual detail.

Description of the trunk

In pointing out the characters presented by the Naples trunk attention will be given, in order, to (a) the rootlets; (b) the general features of the cortical topography including the form and relations of the leaf cushions or bolsters, which will be seen to combine forms characteristic of both *Lepidodendron* and *Sigillaria;* (c) the phyllotaxy; (d) the leaf scar, which illustrates a type peculiar to the Devonic and Lower Carbonic (Mississippian) Lepidophytes; and (e) the leaves. The general form, nomenclature and systematic classification of the tree will be considered later.

The aspect of the trunk as a whole is shown in the photograph one eighth the natural size, plate 1.[1] In the following plate diagram, plate 2, are shown the areas selected for illustration in natural size to indicate the details of various portions of the specimen.

As now mounted the basal section of the trunk, which is dilated like that of the royal palm, is 38.5 cm in width, while the width at the broken top is but 12 cm. The length is 338 cm.

Rootlets. The area imperfectly shown, natural size, in plate 3, figure 1, includes a portion of the lower periphery of the butt of the tree from which fragments of long ribbonlike rootlets stream downward. These rootlets, portions only of which are disclosed, are articulated at large areolate umbilicoid scars, a number of which, like those shown in figures 3 and 4 on the same plate, are still exposed though mostly somewhat distorted by pressure. These cicatrices (X) show the outer ring, corresponding to the attachment of the cortex, the inner ring representing the nerve sheath and the nerve trace itself. The similarity of these scars to the typical scar of Stigmaria will at once be recognized; and it may be added that

[1]On account of the size and position of the specimen it is impracticable to photograph the fossil as a whole. The trunk was first photographed in sections, natural size, and the latter were joined and then photographed as shown in plate 1.

Unfortunately the fossil lies in natural illumination from the right, so that the topography is reversed. The reader is therefore asked constantly to bear in mind that the light is from the right in all figures not specifically designated as otherwise illuminated.

the characters of the cuticle and axial impression of the rootlet agree equally well. In its present condition of preservation on the slab the flattened base of the trunk is subtruncate. It is therefore impossible to determine with certainty whether the tree was provided with the four radiate principal forking roots characteristic of the later Lepidodendreae and Sigillariae. However, since the need for support for so large a tree seems to demand the aid of some type of root we are justified in assuming that the trunk was originally supplied with a more efficient root buttress than the small rootlets now remaining; and since the latter appear to correspond in essential characters to the rootlets of the Carbonic Stigmaria, and since this type is known to be present in the Lower Carbonic, it becomes highly probable that the Naples tree was sustained by roots essentially Stigmarian in character. A notable feature of the Devonic trunk is the large size of the rootlets and areoles as compared with the size of the trunk.

Enlarged base. As shown in plate 1, the base of the trunk is very much swollen in a way suggesting the boles of the royal palm. Throughout the extent of this enlargement the cortex shows evident signs of expansion with the advanced growth of the tree by which the epidermis was probably ruptured and the original rows of leaf cushions were widely separated and displaced. This feature is well shown in plate 4, in the lower part of which, beginning just above the area shown in plate 3, figure 1, the cortical impression is seamed by irregular longitudinal and subparallel narrow ridges probably due to the presence of hypodermal strands. In the upper part of plate 4 the impression of the lower side of the trunk is marked in low rounded, ill-defined, and indistinctly rhomboidal prominences, between which lie the now widely separated and oblique rows of leaf cushions (P). The rupture of the distended cortical tissue between the at first oblique and then mostly vertical leaf cushion rows is more sharply defined a few centimeters higher[1] where, as illustrated in the lower part of plate 5, we have a cortical condition similar to that often presented in the dilated basal portions of the trunks of some Carbonic Sigillariae.[2] Whether the basal dilation of the trunk in the Naples tree was concomitant with a development of secondary (exogenous) wood, can not be determined in the absence of specimens so petrified as to show the internal anatomy. I am, however, inclined to believe that it may have attended a secondary growth.

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[1] See plate 2.
[2] Similar seamed and welted phases of the distended and ruptured bark were described, though not properly, by Lesquereux as Ulodendron.

Formation of the leaf cushions in vertical rows. Traces of the leaf cushions, in distant, irregular and generally oblique rows may be seen down to within 5 cm of the basal periphery of the specimen. In passing upward they become more clearly defined, P, plate 4, on narrow ridges which, higher still, plate 5, become more prominent and more distinctly linear as well as more numerous. Accompanying the rapid contraction of the bole in passing upward the leaf cushion rows become more regular and closer, as is shown in plate 5. The zone of plate 5, 25 to 50 cm above the base of the trunk, is the region of most rapid increase in the number of the cushion rows, as well as of rapid decrease in the diameter of the trunk. The introduction of new rows of leaf cushions, i. e. of new ribs, is distinctly shown at R on plate 6, in which we have about 23 rows at the upper end within a longitudinal zone embracing but 10 rows at the lower border. At the level of the upper border of the plate the impression shows 44 rows on one side of the stem. It is difficult to ascertain exactly the number of rows on the lower portion of the trunk; but on the level of the middle of plate 4, about 45 cm lower, there appear to be but 16 or 17 rows on the impression.

Region of sigillarioid leaf cushions. The upper part of the area in plate 5, and the area situated about 5 cm higher, shown in plate 6, exhibit the passage from the distant and irregular leaf cushion row to the arrangement of the cushions in close, parallel, vertical rows, each occupying the medial zone on the highly convex surface of a longitudinal rib, an arrangement characteristic of the ribbed Sigillariae. It may further be noted that in the upper part of this plate the leaf cushions, S, occupying the greater portion of the width of the rib, are, in the same row, separated by well defined, narrow, transverse furrows which effect a partial segmentation of the rib, while the ribs are separated by sharply defined, narrow, angular furrows, thus presenting the characteristics of the favularian section of the great Rhytidolepis group of the Carbonic Sigillariae, with the exceptions of the differences in the leaf scar itself, and the phyllotaxial angle. The similarity to the ribbed Sigillariae is further seen in the parallel hypodermal strands, which in the partially macerated portions of the cortex are seen to traverse the slightly zigzag intercostal furrows, H, plate 6.

From the level of the area shown in plate 6, the distinctly sigillarioid type of cortex with the leaf cushions on narrow longitudinal ribs continues for some distance, while the ribs themselves become

somewhat narrower so as to emphasize the favularian aspect as is illustrated at about 80 cm from the base of the trunk in plate 7, figure 1. In this area the lateral cicatricules (parichnoi) of the leaf scar are unusually clear in subepidermal impression, where they appear to unite below in a narrow horseshoe form.

The surface shown in plate 7, figure 3, is included in a fragment of the counterpart impression of a portion of the trunk, at a level about 90 cm from the base. It illustrates[1] the distinctly vertical alinement of the leaf cushions, which are becoming elongated in an obovate-elliptical shape, the form of the leaf scars themselves, and the hypodermal strands seen in the partially macerated upper central area. The small portion, at a point a little lower on the trunk, shown in figure 1, includes an area in which the ribs are less macerated and well rounded, with but slight constriction between the leaf cushions.

In plate 8 is shown, natural size, a portion of the actual carbonaceous residue of the trunk itself. The specimen, the impression of which is in part shown in plate 7, figure 3, comes from near the center of the trunk and is but 4 mm thick along the middle, the thinner, fragile, carbonaceous borders being lost. It is, however, particularly interesting as showing the outer surface of this portion of the trunk. The outlines of the leaf cushions, which are observed to be more prominent near their upper ends, are well defined, while the leaf scars are in most cases recognizable. It is to be noted that the cushions are nearly bilateral though the elongation approaches the lepidodendroid form and the spirality of arrangement is distinct in the area on the upper right.

Region of lepidodendroid form of leaf cushion. It has been seen that in the lower areas examined the leaf cushions are alined on very distinct longitudinal costae, from which they slightly protrude. However, in passing upward we find a gradual change to a leaf cushion form and relation more nearly characteristic of Lepidodendron. Even at some distance below the middle of the fossil the compressed cushions often present a lepidodendroid form near the border of the stem. An example of this is shown in plate 7, figure 2, from an area but 85 cm from the base, where we find, on the left, closely placed, indistinctly rhomboidal impressions of cushions which are more clearly spiral in arrangement and which appear to overlap somewhat obliquely in the longitudinal sense. These approach a Bergeria stage; but the cushions on the right, in the medal zone of

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[1]This figure is shown in light from the left.

the fossil, appear narrower and are plainly in vertical series on ribs.   It is probable that the form of the lepidodendroid cushions in this area is in part due to obliqueness of compression as will later be explained.

From a hight of 80 cm upward the lepidodendroid form of cushion is constantly more or less in evidence, first along the borders of the fossil, and later throughout its width.   The marginal occurrence of rhomboidal cushion impressions is also illustrated, in plate 9, figure 1, from an area 150 cm above the base, where again we find the medial costae relatively narrow, though the cushions, especially on the right near the borders, are broader and slightly overlapped obliquely in the same vertical row.   The width of the medial rows is evidently foreshortened by lateral pressure in the process of the flattening of the trunk.   This foreshortening indicates the destruction of the inner tissues of this part of the trunk before the compression of the outer cortex.   A discontinuity of the cushions and an absence of lateral symmetry are apparent on the right of the photograph, which represents nearly the entire width of the fossil at this point.   The small area, shown in plate 9, figure 3, about 10 cm higher than that in figure 1, is characterized by broad and unusually compact cushions with more elongated leaf scars.   In outline the cushions are lepidodendroid and wholly without costate arrangement, although ill-defined ribs, largely the result of pressure, appear near the median line of the stem.

In that portion of the trunk above 175 cm from the base the lepidodendroid form of leaf cushion is overwhelmingly dominant though narrow medial costation is still to be seen for some distance farther.   The surface at 210 cm shown in plate 9, figure 2, presents a still more elongated and asymmetrical obliquely overlapping leaf cushion, whose spiral arrangement is, for the most part, far more distinct than the vertical alinement.   The cushions shown in figure 2, like those seen at 270 cm in plate 10, figure 2, and especially at 285 cm in plate 10, figure 3, are distinctly lepidodendroid even to a slight basal truncation, and are practically without costate arrangement.   They represent the common Devonic lepidophytic type, referred by all authors to the genus Lepidodendron.

Near the top of the fossil the Lepidodendron form of leaf cushion is present even along the median line, as may be noted

in the segment extending to 325 cm shown in plate 11. In this region the leaf cushions are elongated, close, indistinctly fusiform, more prominent at the upper end, asymmetrical, and distinctly spirally arranged. In other words, so far as concerns form and topography the leaf cushion is nearly typical of Lepidodendron.

Knorria condition of cortex. An interesting feature presented by the Naples tree is the existence of a region of Knorria condition[1] at about 225 cm from the base. This is shown in an area, plate 10, figure 1, in which, on the right, we see the broken remains of the elongate, narrow-rounded nerve trace sheaths passing nearly erect upward and outward to the underlying and concealed surface of the bark, those below being imbricated over those emerging higher in the trunk. The fragments still adhere to the impression of the outer cortex, their broken, inner ends projecting downward. Where removed, a little to the left of the middle, we see the narrow leaf costation, which toward the border, still further to the left, yields to the lepidodendroid type of cushion. It will be noted that the sheath casts appear to widen upward to the full breadth of the rib. In the area partially shown in figure 2, in the same plate, we see the expression of these sheaths very obliquely emerging to the narrowly rhomboidal or fusiform cushions, and passing to the leaf scars themselves. The Knorria stage or structural type is known in the cortices of Lepidodendron, Bothrodendron, and the Asolanus group, or Subsigillariae.

Phyllotaxy of the tree. The seemingly anomalous occurrence of the favularian (sigillarian) costate type of leaf cushion in one part and of the lepidodendroid type in another part of the same individual trunk finds its explanation in the Knorria stage just described and in the character of the disposition (phyllotaxy) of the leaf cushions on the trunk.

The plan of the leaf cushion distribution is well shown in figures 1 and 2, plate 7, or any of the other areas in the lower part of the trunk. In the portions cited we find a very distinct alinement in vertical rows, a fairly clear horizontal alinement, and less conspicuous oblique rows at an angle of approximately 45°. The scars alternate in the transverse rows which are at an angle averaging very nearly 90° with the longitudinal

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[1]The name Knorria was applied to a Lepidodendron cortex in which, as the result of partial maceration of the tender tissues of the inner and middle cortexes, the casts of the leaf trace sheaths, spirally arranged and usually very oblique or appressed, are shown as imbricated scale points, in aspect suggesting spirally placed erect slivers. It was at first regarded as a valid genus, but was later recognized as merely a condition of preservation of certain lepidophytic stems.

rows; and the orthostichy is therefore approximately 90°. Lines connecting the centers of any group of four proximal scars will form a rectangle in which the hypothenuses are vertical and horizontal. The passage from the favularian to the lepidodendroid type of leaf cushion arrangement is primarily due to the combined effect of the rapidity and direction of growth on the one hand and the phyllotaxy on the other.

In the lower portions of the trunk, in which the ribbed type of cortex is most strikingly developed, plate 6, the cushions in the same vertical row are very close as the result of relatively slow linear growth. At the same time the lateral expansion or thickening of the trunk has widely removed the rows, especially near the base, as seen in plate 5. Thus, in the plate just cited the leaf scars may be but 3 mm, or less, distant from center to center in the same row, while at 90 cm from the base they are 7 mm distant. Near the top they become about 11 mm distant. At the same time, in passing upward we find the ribs growing narrower, and the vertical rows coming more closely together, not merely as the result of the introduction of new rows, but by reason also of greater linear growth as compared with the transverse increase in the size of the tree. As the cushions in the vertical rows become more distant and the lateral cushions crowd closer we find the rhomboidal type appearing near the periphery of the impression, and later in the median zone.

Referring again to the Knorria stage illustrated in plate 10, it will be seen that the narrow ribs correspond to the vertical rows of nearly erect and imbricated nerve-trace sheaths whose more resistant structure makes their presence known even when the outer cortex and cushion tissue is but partially shrunken, as in figure 2 of the same plate. When the hollow cortical cylinder was flattened and the median portion of the fossil foreshortened by lateral pressure, the rows of more rigid sheaths undoubtedly controlled the clear alinement and strong topography of the median ribs, whose present narrowness is due to the lateral pressure. There is little room for doubt that the presence of ribs in the median portion of the upper part of the trunk is chiefly due to the resistance of the nerve sheaths. No doubt they also contributed to the prominence and rigidity of the costae in the lower part of the trunk. Where the pressure was oblique to the surface, as near the lateral borders in the areas

shown in plate 7, figure 2, or plate 9, figure 1, the obliquely
ascending sheaths were crowded somewhat to the side so as
more readily to obliterate the longitudinal seriation.

The transition from the distinctly sigillarian arrangement of
the leaf cushion to the dominantly lepidodendroid type is con-
comitant with the relative increase of the vertical distance
between the leaves in the same row on the trunk; and it is
consequent to the more rapid longitudinal growth of the tree
by which the leaves are farther removed from one another in
the vertical sense, and the more distant sheaths are not com-
pactly overlapped so as to form a continuous row or ridge.

The rectangular phyllotaxy seen in the Naples tree is in gen-
eral characteristic of the Devonic Lepidophytes, and is present
also in the Carbonic Bothrodendron (Subsigillariae). When the
slow longitudinal growth, without great expansion of the cortex,
has brought the leaf scars into very close relations vertically,
the leaves have in some cases been described as verticillate.[1]
Continuous impressions of the escaping nerve-trace sheaths in
longitudinal rows, all the more distinctly defined through the
partial maceration of the softer tissues so as to form narrow
ribs, are also to be observed in many of the fragments reported
as L e p i d o d e n d r o n g a s p i a n u m. In the higher Car-
bonic Lycopods the rectangular phyllotaxy or pseudo-verticillate
arrangement is seen in the Sigillariae, and in the strobilar axis
of Sigillariostrobus, or even in Lepidostrobus.

Leaf scar. The leaf scar of the Devonic fossil, like those
of the Carbonic Lepidodendron and Sigillaria is placed on the
upper part of the leaf cushion, and on the most prominent area
of the latter. In general it is very regular in form, slightly
obovate, or oval-obovate, rounded below and slightly cordate
at the upper border. Illustrations from the lower or sigillarioid
portion of the trunk are shown in plate 6 at S, while examples
higher in the specimen are seen in plates 7, 8 (in relief), and 10.

Within the sinus at the upper edge of the leaf scar, plate 10,
figure 4, is a fairly distinct ligular pit, similar to that seen in
the Carbonic Lepidophytes. It is interesting to find the ligule,
so characteristic of the Paleozoic predecessors of the Lycopodiales,
already present in the upper Devonic type.

The passage of the nerve trace, or vascular bundle, to the
leaf is marked by a punctiform scar slightly above the middle

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[1] e. g. L e p i d o d e n d r o n c o r r u g a t u m var. v e r t i c i l l a t u m from the lowest
Mississippian.

of the leaf scar. On either side of the nerve trace, and at but little distance within the lateral border of the scar, is situated a vertically elongated and slightly crescentic cicatricule, the cross-section of a loosely parenchymatous transpiratory tract. The cicatricules (parichnoi) are slightly hooked inward at the upper ends, figure 4, while in the subepidermal impression they are found to coalesce in an ovate figure embracing the nerve trace.[1] No distinct trace of appendages has been observed.

By the characters of the leaf scar the Naples tree is more closely related to Bothrodendron and Sigillaria than to any representative of the Lepidodendreae. The rounded form of the scar suggests Bothrodendron, though the vertically elongated parichnoi are comparable only to those of certain Sigillariae, especially the Rhytidolepis group. By its combined characters the scars of the Devonic trunk differ however, from both Bothrodendron and Rhytidolepis, the two oldest representatives of their respective groups.

Leaves. The leaves of this type of tree appear to have remained attached for a long time, since some of them are persistent as low as but 70 cm from the base of the trunk. As shown on the left border in the lower middle, at L in plate 11, and in figure 3, plate 10, they are short, not over 3 cm in length, very narrow, and somewhat lax. In this fossil which comprises the older portion of the trunk they stand out at nearly a right angle, or are even slightly reflexed. The base of the leaf is conically enlarged to coincide with the leaf scar, and this portion seems to have been largely composed of soft and very perishable tissue. The nerve trace is clearly marked, while on the sides there is evidence of the boundaries either of parichnoian zones or of a large sheath which may be traced in gradually converging lines nearly to the apex.

The small size, usually rather lax form, enlarged base, and persistent habit are in general characteristic of the leaves of the Devonic group to which the Naples tree belongs.

General relations of the tree

The examination of the magnificent specimen from Naples shows that although it appears to represent a synthetic type antecedent to the later Paleozoic Lycopodiales it is none the

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[1] In many of the subepidermal impressions, plate 7, figure 3, the prominent cicatricule strongly resembles the corresponding sigillarian homologue once generically described as Syringodendron.

less a well developed Lycopod, and not the most simple in its organization. It is even possible that it developed secondary wood in the dilated butt.

Its base was provided with stigmarioid rootlets and was presumably supported by some type of stigmarioid root, though the other contemporaneous Devonic material yet found does not justify the assumption that it was associated with the long roots typical of Stigmaria.

We have seen that the leaf cushion form in the lower portion of the trunk is characteristic of the favularian ribbed Sigillariae, while that higher on the trunk is equally characteristic of the Lepidodendreae. The leaf cushions differ, however, from Lepidodendron by the phyllotaxy; from Sigillaria by their narrowly rhomboidal form; and from Bothrodendron by the development of ribs and definite leaf cushions which, in conjunction with the relative linear or lateral growth of the axis, results respectively in the lepidodendroid or the sigillarioid aspect of cortex.

The costae are due to the vertical alinement of the cushions and the presence of a resistant nerve trace sheath which traverses the cortical tissue and which becomes imbricated in a longitudinal ridge when the surrounding tissues have shrunken. Partial decortication displays these sheaths as a Knorria condition, a condition found in Lepidodendron, Bothrodendron and Asolanus (Subsigillariae).

By its leaf scars the Naples tree is most closely related to Bothrodendron and the Rhytidolepis Sigillariae. It differs from the former by its elongated parichnoi and from the latter by its obovate form. On the whole it is nearly intermediate to the two groups.

The leaves of the fossil trunk are in character nearest those of Bothrodendron, especially in respect to their basal dilation, though in aspect they closely resemble those of certain Lepidodendra. The persistence of the leaves is characteristic of the Devonic group to which the trunk belongs.

Although this group has nearly always been described as Lepidodendron, its special resemblance to the latter is confined to the development of narrowly rhomboidal prominent leaf cushions and to the habit of the leaves. Bothrodendron sometimes exhibits distinct rhomboidal leaf cushions[1] in the small twigs though its cortical surface is flat and shagreened in the larger members. In the Sigillarian group the nearest relatives

[1]See Weiss & Sterzel. Die Gruppe der Subsigillarien. 1893. pl.1, fig. 3.

appear to be among the Rhytidolepis and favularian species. Taking into account the importance of leaf scar characters it is probable that the Naples tree is more closely bound to the former (Rhytidolepis) which seems also to have been geologically the earlier to appear. With this and Bothrodendron (Cyclostigma) it would seem to be nearly equally allied, its connection with the latter being possibly the more intimate.

When living the tree was probably nearly a foot in diameter at the enlarged base. From this it rose straight, tapering fast at first, and then very gradually. It has already been noted that no branches were present up to the end of the fossil at a hight of 5 meters where it measured but 7 centimeters in width. It seems probable, therefore, that branching was rare. We may conceive of the tree as gently tapering and finally dichotomizing in slender, arching, and very distinctly forked, gracefully drooping branches to which the open, short, persistent leaves imparted a plumose aspect. It is possible, however, that the branches may have been clambering or sprawling, rather than pendent in habit.

Unfortunately neither the specimen in the Museum nor its associates have afforded any petrified portions by which satisfactorily to ascertain the features of their internal anatomy. We may, however, I believe, conclude that a periderm situated in the outer cortex and capable of permitting a growth of exogenous bark was present. If there was any development of an exogenous or secondary growth of wood in the trunk, as seems possible, it was probably confined to the region of the dilated base.

Systematic position and name of the fossil

Fragments of the impression or of the counterpart of the fossil trunk were sent by Dr Clarke, the State Paleontologist, to Sir William Dawson, by whom they were identified as belonging to the species described by Rogers[1] from the Devonic of Pennsylvania as L e p i d o d e n d r o n   p r i m a e v u m . As to the specific identity of the two plants there is little doubt, and the specific term, p r i m a e v u m , should be attached to the New York fossil, though it can not be retained in the genus Lepidodendron.

The Naples tree differs generically, as we have seen, from all the Carbonic Lycopod groups by the peculiar combination

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[1]Geol. of Pa. 1858. v.ii, pt 2, p.828, fig. 675.

of leaf cushion characters and arrangement, by the form and details of its leaf scars, and by its persistent small leaves which are more or less distinctly conical at their bases. Comparison of the fossil with other and less imposing fragments of Devonic Lycopods shows it to be one of the more highly developed representatives of a fairly distinct archaic group foreshadowing the later genera Bothrodendron (Cyclostigma), Sigillaria, Lepidodendron, and Lepidophloios. Among the members of this ancient group is the plant from the Devonic of New York figured by Vanuxem[1], and later named[2] S i g i l l a r i a v a n - u x e m i by Göppert in his great work on the *Flora of the Transition Series*. The present repository of Vanuxem's type specimen is not known to me and I have therefore not been able to consult it. However, the collection of the State Geological Survey contains a similar specimen combining the lepidodendroid and sigillarioid forms of leaf cushion and probably belonging to the same species. To the Vanuxem plant, with which the Naples tree is certainly congeneric, Mr Kidston,[3] the distinguished British student of Paleozoic plants, has given the special generic name Archaeosigillaria.

After the examination of the greater part of the lepidophytic material from the North American Devonic I am convinced that by far the greater number of the forms described as Lepidodendron from the Middle and Upper Devonic of this continent are referable to the genus Archaeosigillaria. It should be noted, however, that the name applied by Professor Kidston is possibly preoccupied by Protolepidodendron, earlier proposed by Krejči.[4] The generic relation of P r o t o l e p i d o d e n d r o n s c h a r i a n u m , the type of the genus, to Archaeosigillaria is at present uncertain since Krejči did not illustrate his specimens, and the later publications by Stur[5], and by Bernard and Potonié[6] leave doubt as to whether Krejči's original specimen is not characterized by bifurcation of the leaves. The question of the generic nomenclature will be discussed more fully in a later paper treating in a somewhat detailed form many of the lepidophytic types from the Devonic of the eastern United States.

[1]Geol. N. Y. 3d Dist. 1842. p. 184, fig. 51.
[2]Foss. Fl. d. Uebergangsgebirge. 1851. p. 200.
[3]Nat. Hist. Soc. Trans. Glasgow. 1901. n.s. v. 6, pt 1, p. 38.
[4]Sitzb. k. böhm. Gesell. Wiss. 1879. p. 203.
[5]Sitzb. k. Akad. Wiss., Wien, Math. Nat. Cl. 1881. v. lxxxiv, Abth. 1, p. 333.
[6]Fl. Dév. Etage H de Barrande. 1905. p. 40.

Whether or not the Bohemian and Naples types are congeneric, I do not hesitate to place them in the same ancestral group, though recognizing in Protolepidodendron scharianum a form probably more primitive and ancient than Archaeosigillaria primaeva. This group, which contains the oldest known Lepidophytes, appears to be of family rank and may appropriately be given the family name Protolepidodendreae.

PLATE 1
PLATE 2

Fossil trunk of the Naples tree, A r c h a e o s i g i l l a r i a
p r i m a e v a , in the State Cabinet of Natural History. Photo-
graphically reduced to ⅛ the natural size.

Diagrammatic outline sketch, in the same reduced size, of the
fossil, showing the relative positions of the rectangular areas
illustrated in natural size in the following plates, the numbers
of which are indicated by bold-faced type.
The distances, in meters, from the base of the trunk are shown in
smaller numerals on the right.

FOSSIL TREE

Plate 1
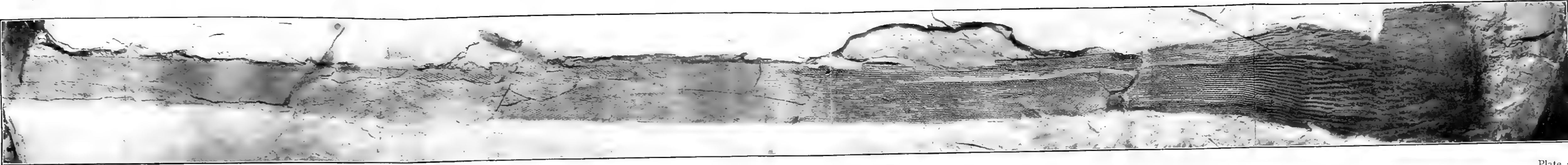
Plate 2
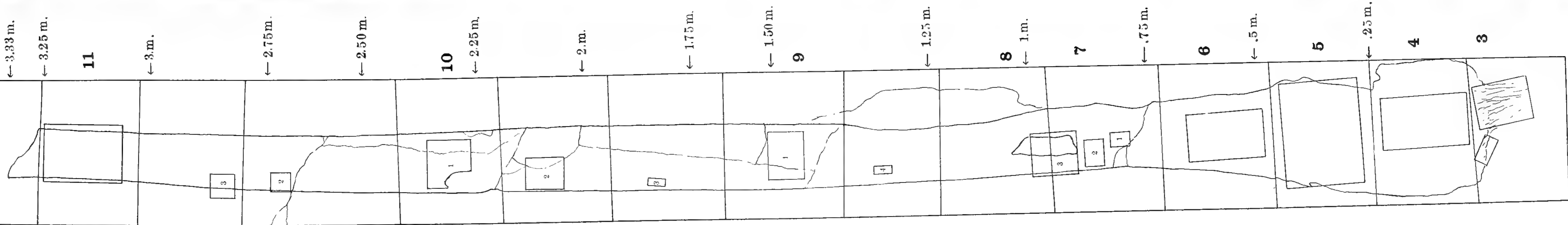
1 Portion of the truncate base of the fossil trunk, bearing scars (X) of the typical Stigmaria from which slender, collapsed, ribbonlike rootlets stream downward in the shale matrix. The latter, which agree in superficial characters with the Carbonic forms, are seen in plate 1 also, proceeding directly from the truncate base, no large bifurcating roots being shown in the specimen.

2 Small area showing stigmarian cicatrices (X) more distinctly.

3, 4 Details of stigmarian cicatrices, slightly enlarged.
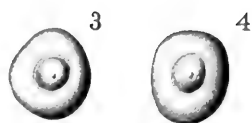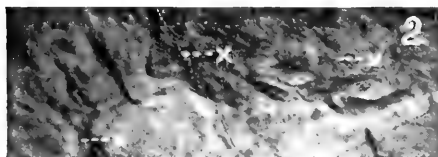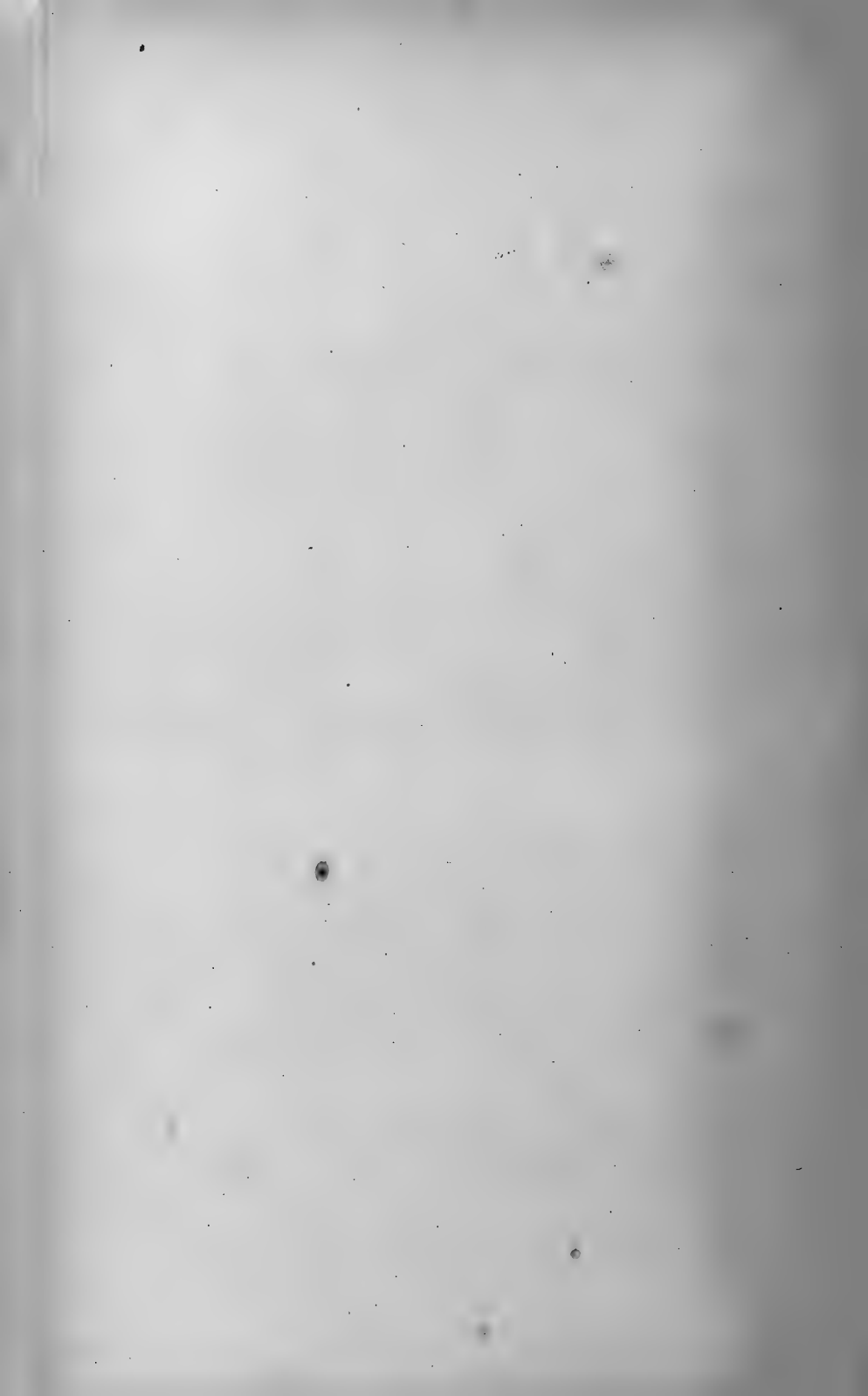
Surface of area just above base [*see* diagram, pl. 2, no. 4], showing greatly dilated cortex, seamed, and marked by very distant and oblique though irregular rows of leaf cushions (P), the individual cushions being very close, serially, in each row. The irregularly rhomboidal depressions between the leaf cushion rows are characteristic of the lower part of old trunks of Sigillaria and Lepidodendron.
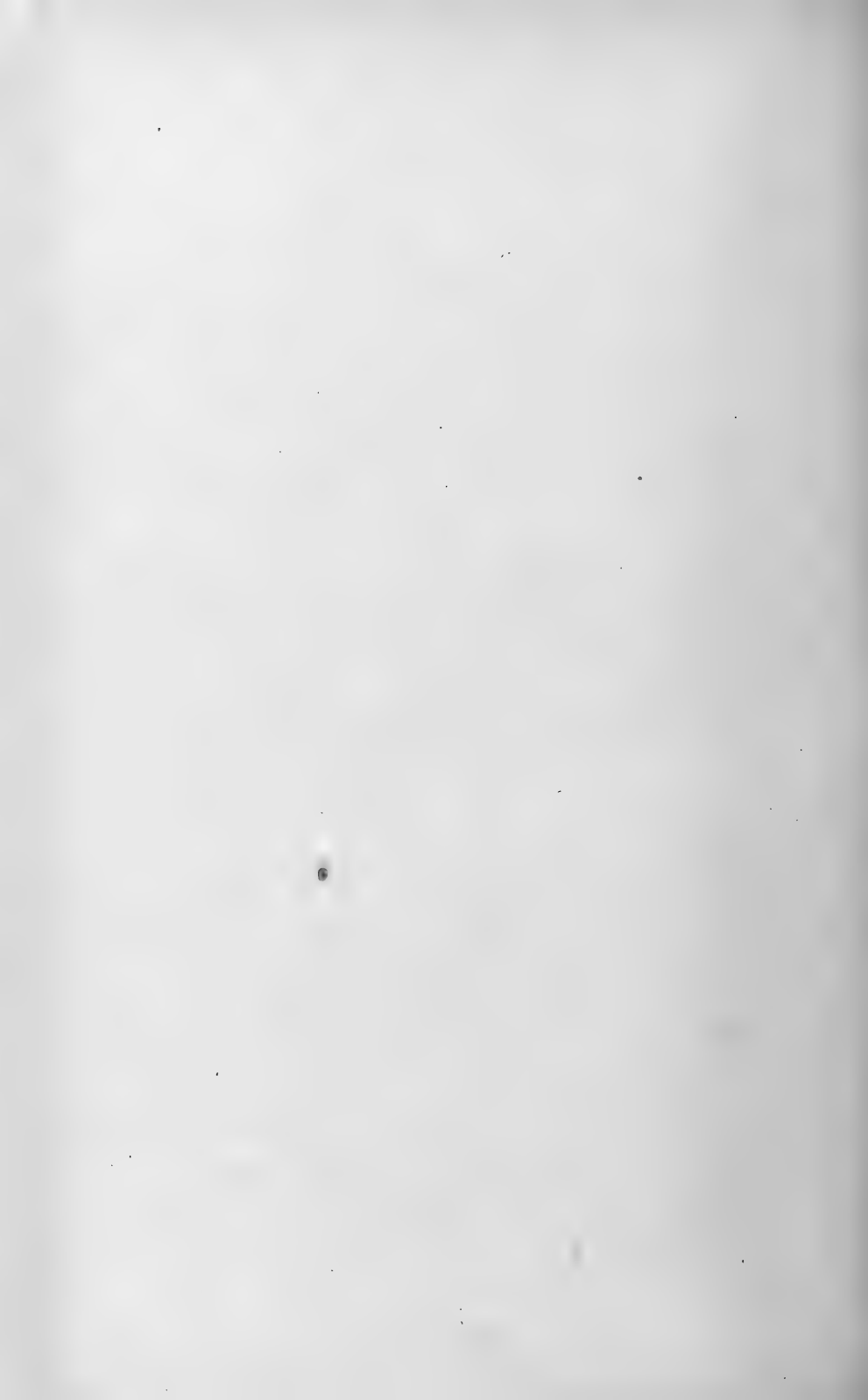
Area, including nearly the entire width of the impression, about 5 cm above that shown in plate 4. The impressions of the leaf cushion rows are becoming more regular and distinctly longitudinal, while the number of rows is increased by the introduction of new ones. The individual cushions are less compactly alined in each row near the upper end of the area here shown. This is the region of rapid contraction above the enlarged base of the tree. [*See* pl. 2, 3]

Plate 5

Portion of the impression of the trunk about 5 cm above that shown in plate 5. The leaf cushions are borne in sigillarian arrangement on narrow ribs, the intercostal furrows (H) being slightly zigzag, as in the section Favularia. New ribs (R) appear at various points. The leaf cushions on the left are favularian in aspect, and, though the impression is subepidermal over portions of the area, the outlines of the obovate or oval leaf scars (S) are seen at many points.

1 Surface with narrowly rounded longitudinal leaf cushion ribs; about 80 cm from the base of the tree.

2 Detail from area, a little higher, in which the cushions are in a distinctly costate arrangement on the right (near the middle of the stem), though on the left they assume a rhomboidal form, an aspect like those of Lepidodendron. The leaf scars, including the parichnoian cicatricules, are more distinct on the ribs, whose sharp configuration is probably due in part to lateral pressure.

3 Fragment of the impression of the counterpart, or upper side of the stem, at about 90 cm above the base, showing favularian cushion rows, with traces of hypodermal strands along the intermediate furrows.

Fragment of the carbonaceous residue of the flattened tree trunk, from the region shown in part, as an impression, in plate 7, figure 3. The longitudinal costate arrangement of the elongated leaf cushions, bearing the obovate leaf scars, is seen in the middle, while a spiral arrangement becomes more distinct on the right.
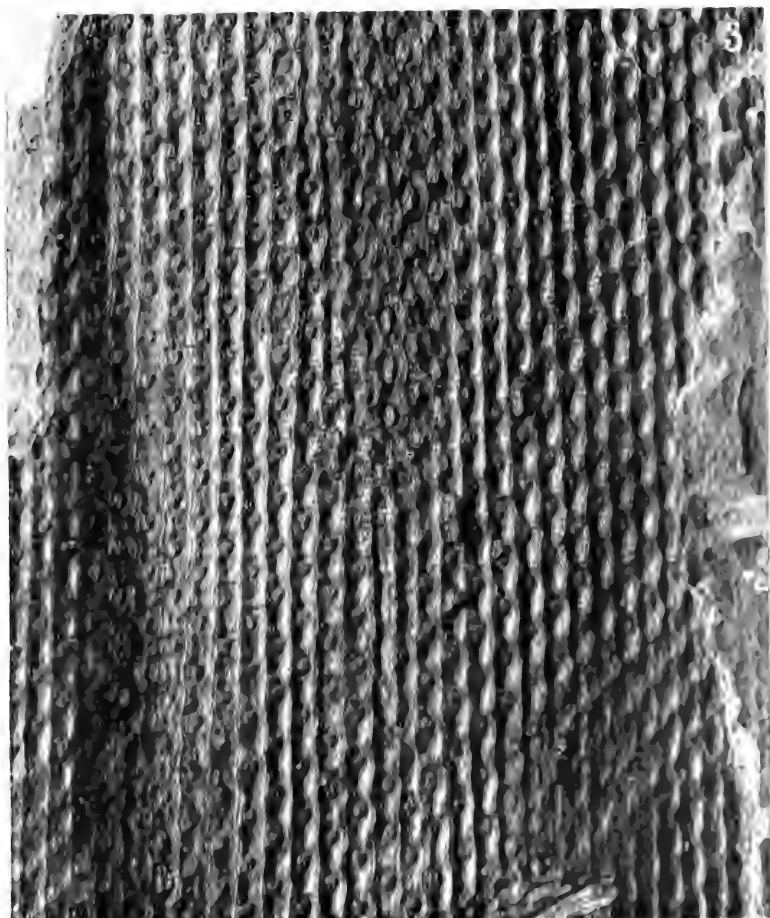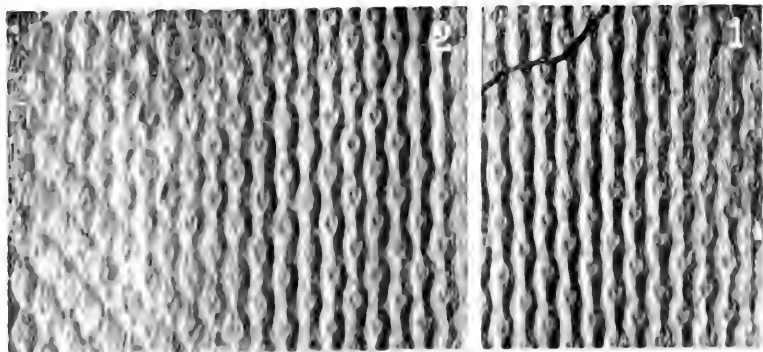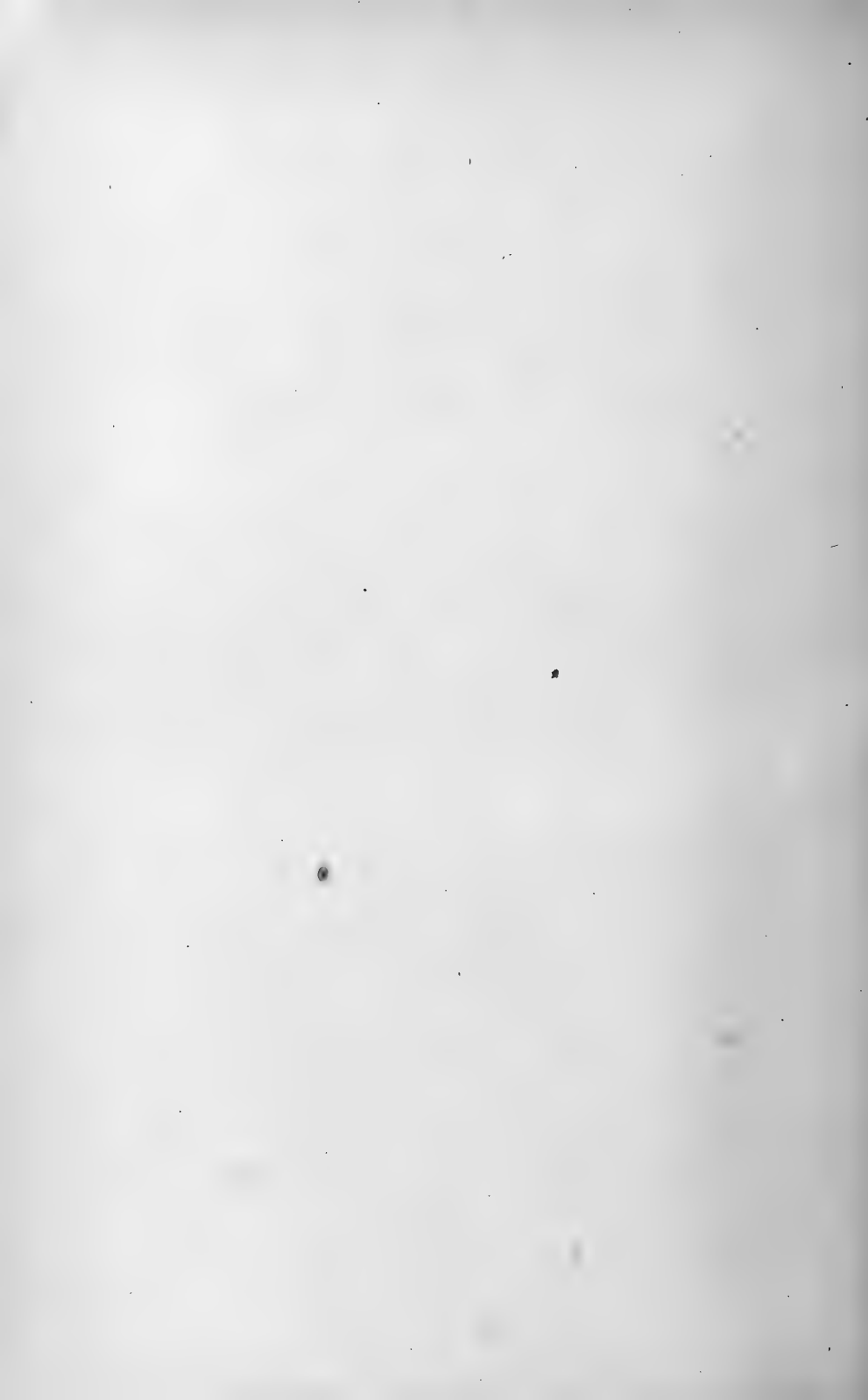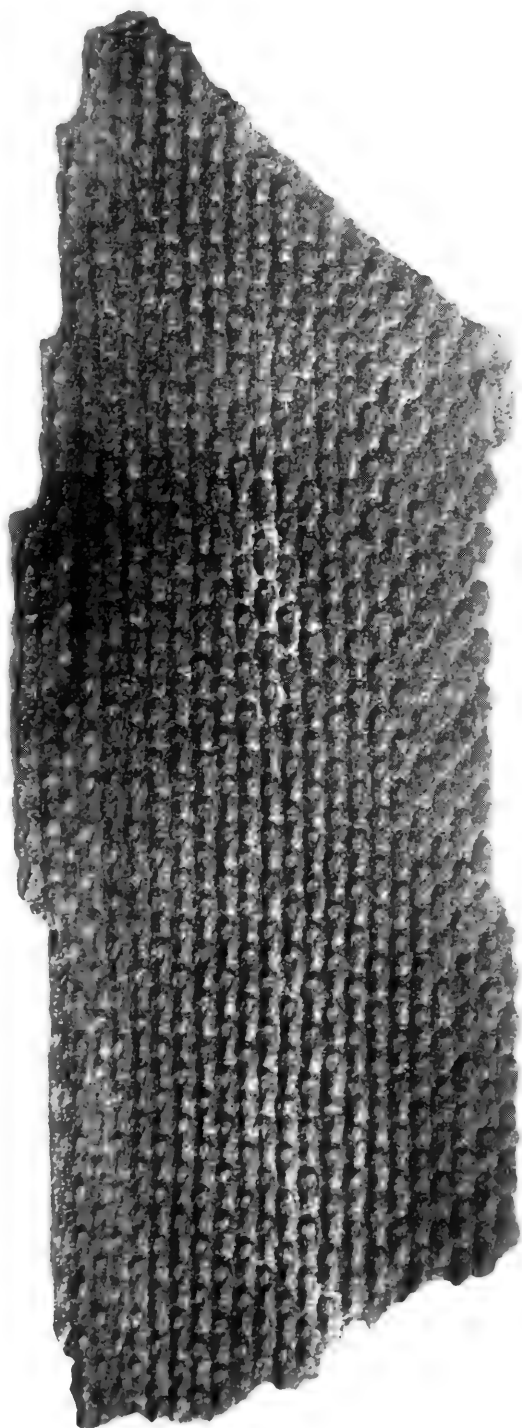
Plate 8

: **PLATE** 9

Figures in natural size; lighted from the right

1 Area from 150 cm above the base, representing that portion of
   the tree in which the development of the Lepidodendron form
   of leaf cushion begins to dominate. The sigillarioid ribs along
   the center are narrowed and exaggerated by lateral pressure.
   A relatively broad rhomboidal type of cushion is seen on the
   sides.
2 Cortical impression at 210 cm above the base, at and extending
   to the left of the center; the median portion of the cortex is
   very narrowly compressed, the lateral, on the left, showing
   the lepidodendroid fusiform cushion, in which, as on the right
   in figure 1, the impression of the leaf bundle sheath is shown
   through the partially macerated surrounding cushion tissue.
3 Small area near the border of the impression, at about 180 cm
   above the base, illustrating a short form of lepidodendroid leaf
   cushion.
4 Small area, at about 130 cm above the base, in which the leaf
   scars occupy nearly the entire width of the longitudinal ribs.
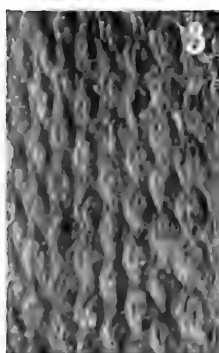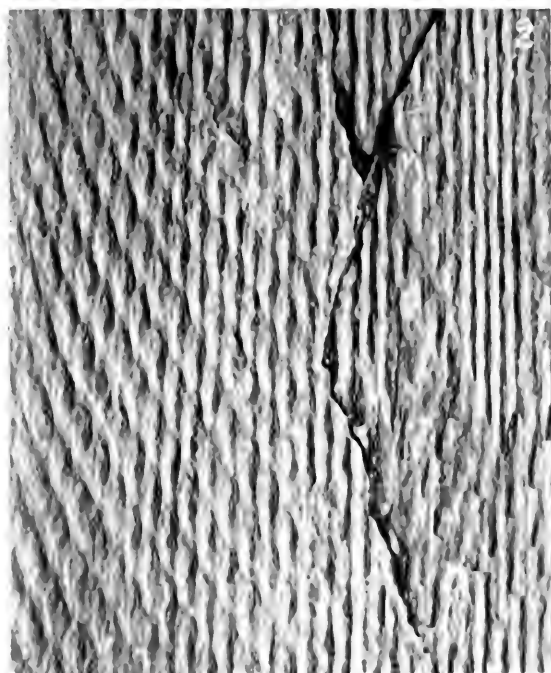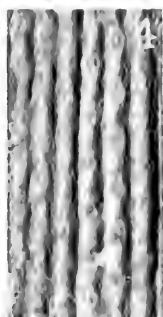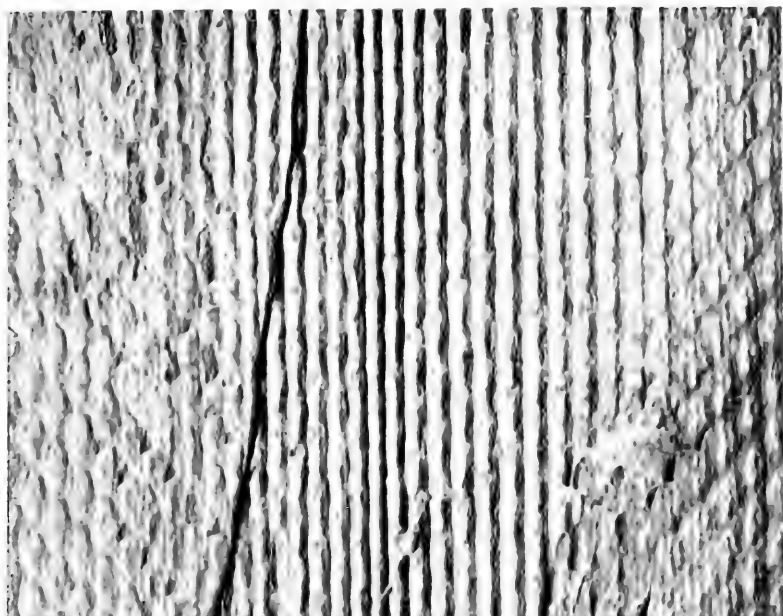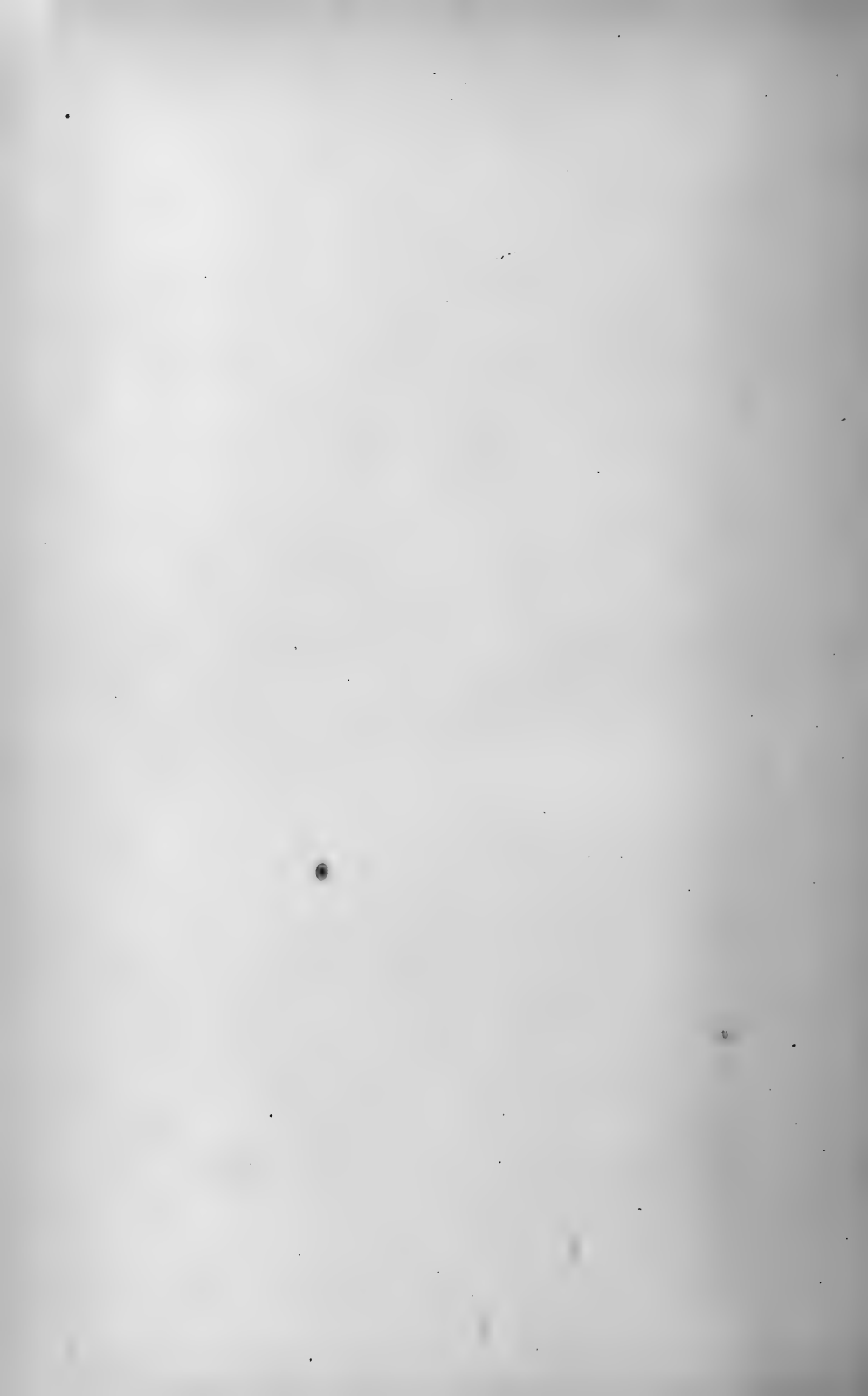
1 Portion, at 225 cm from the base, in which, on the right, the impression retains partial casts of the leaf trace sheaths passing very obliquely upward and outward, the stage of preservation over a part of the area being that known as Knorria. The costation is narrowed and exaggerated over the median line of the trunk, while in the upper left the cushions present the fusiform (lepidodendroid) type in distinctly spiral arrangement.

2 Cortical impression, at 275 cm from the base, in which the partially macerated tissue permits the expression of the obliquely emergent nerve trace sheaths.

3 Marginal area, at 280 cm from the base, showing the elongated form of lepidodendroid leaf cushion. Along the left border several leaves (L) are seen still attached to the bolsters. Figure 3 is inverted.

4 Slightly enlarged detail of leaf cushion from nearly mid-length of the trunk, showing the obovate leaf scar, the ligular pit just above it, and the nerve trace above the center of the scar.

5 Portion, enlarged, of rib showing leaf cushion, leaf scar and the greatly elongated parichnoian cicatricules which are usually slightly in-hooked at the top and which tend to meet in the lower part of the leaf scar so as to form a horseshoe-shaped cicatricule nearly embracing the nerve trace.

6 Enlarged and semidiagrammatic detail of the leaf still attached to the cushion.
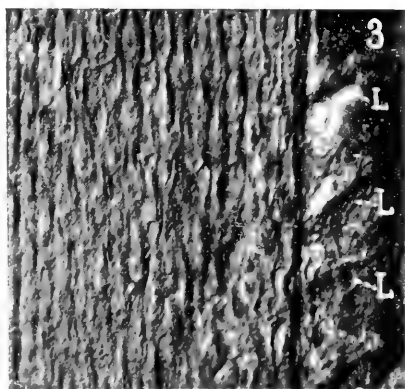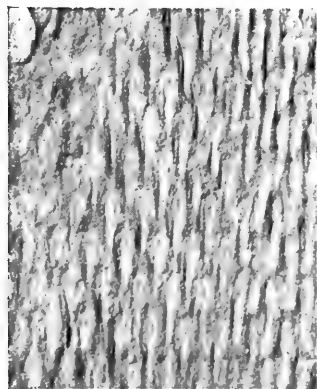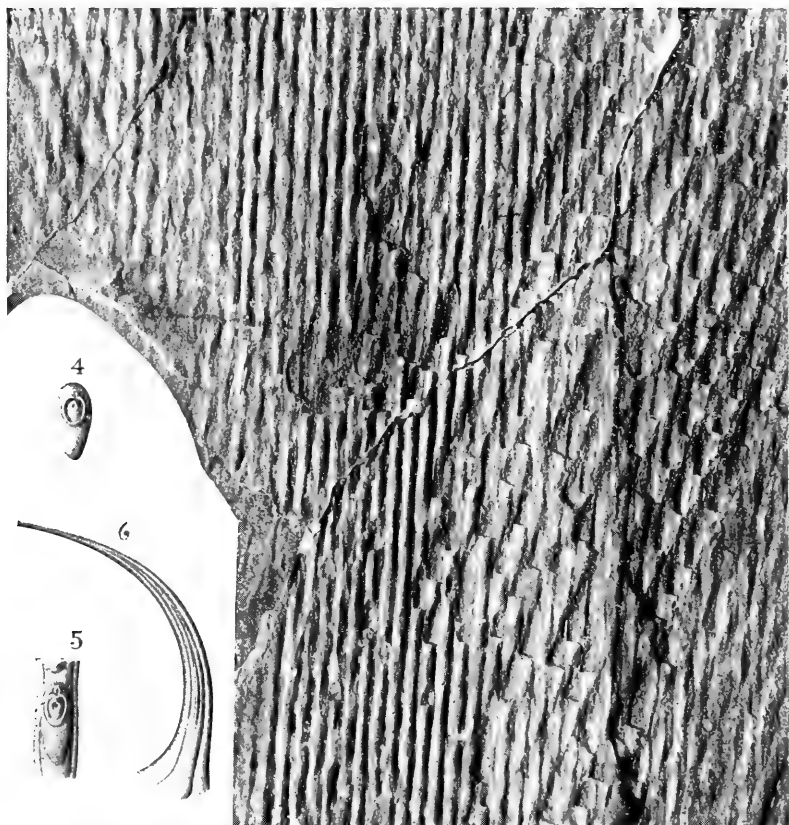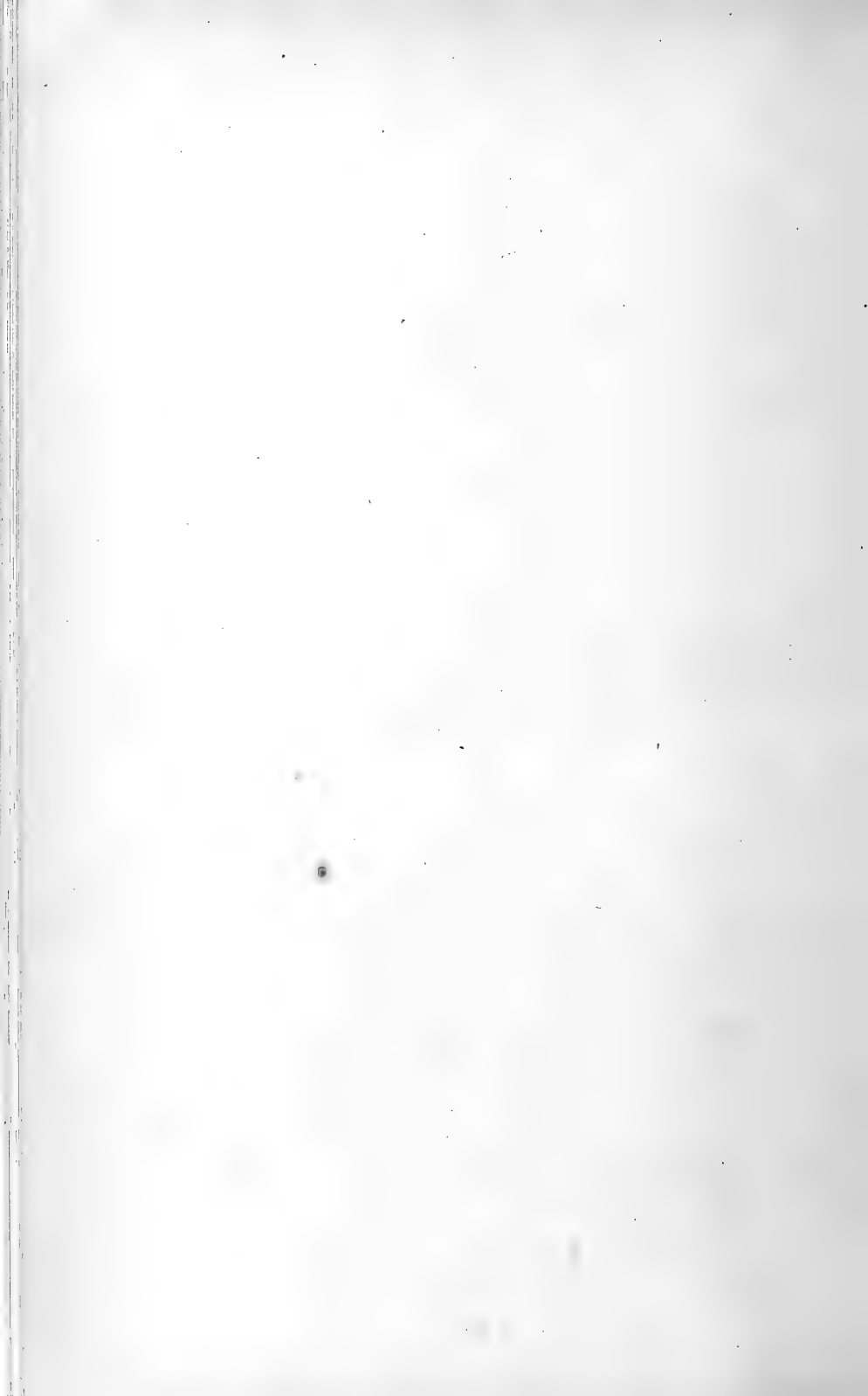
Segment very near the top of the fossil trunk, which in this region presents exclusively lepidodendroid cushions in distinctly spiral arrangement. In many cases portions of the leaf cushion tissue adhere to the rock. At the left several rather abruptly reflexed leaves (L) may be seen.

STRUCTURAL AND STRATIGRAPHIC FEATURES

OF THE

BASAL GNEISSES OF THE HIGHLANDS[1]

BY

CHARLES P. BERKEY

General statement

The lowest and oldest, as well as the most complex in structure and rock variety, of all the formations of the Highlands region of southeastern New York is essentially a series of gneisses. Geographically they extend in a succession of ridges, separated by belts of limestone and schist, with a northeast-southwest trend on the east side of the Hudson river from New York city to the Highlands proper. These separating belts cease in the vicinity of Peekskill and Tompkins Cove, a distance of 40 miles from New York. From that locality northward the gneisses constitute almost the whole areal geology, to the northern limits of the Highlands, forming a broad elevated and rugged belt about 20 miles wide whose chief structural features trend northeastward in essential conformity with the ridges of the southern district. Toward the west, below Peekskill, the series is abruptly terminated at the Hudson river. The only other outcrops of these ancient rocks occurring on the west side of this line are at the extreme southern part of the district in Jersey City and Staten Island. Above Peekskill in the Highlands proper the same rocks cross the Hudson and continue southwestward into and through northern New Jersey. On the eastern side this formation and its overlying relatives pass into Connecticut.

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[1]The observations upon which the present paper is based were made almost wholly in the Tarrytown and West Point quadrangles as outlined by the topographic maps. This work, which consisted of careful mapping in these areas, was supplemented by numerous expeditions into the adjacent Harlem, Ramapo, Skunnemunk, Newburgh and Poughkeepsie quadrangles, and has occupied portions of two summers.

OUTLINE MAP OF SOUTHEASTERN NEW YORK
Adapted from the geological map of New York
Showing position of the Tarrytown and West Point quadrangles and distribution
of the larger masses of ancient basal gneisses constituting the Highlands

Petrographic range

No single type of rock can be selected as a constant for this formation. Certain varieties are more abundant than others and thereby give the complex series a certain character that serves to distinguish it from all others of the region. But in isolated outcrops of limited extent an abnormal or unusual type may cause great uncertainty of identification.

Broadly, though, the formation includes banded granitic, hornblendic, micaceous and quartzose gneisses; mica, hornblende, chlorite, quartz and epidote schists; garnetiferous, pyritiferous, graphitic, pyroxenic, tremolitic and magnetic schists and gneisses; crystalline limestone, serpentinous limestones, ophicalcites, serpentine, tremolitic limestone and quartzite; pyrite and magnetite deposits; granite and diorite gneisses; true granite, diorite and gabbro bosses; numerous dikes, stringers and lenses of pegmatite; and occasional basaltic, diabasic, and andesitic dikes. All of these occur with many variations and gradations such as can be seen only in an area of extreme metamorphism and many dynamic disturbances.

Of these the most abundant are the banded hornblendic, micaceous and quartzose gneisses, and the more massive granitic gneisses. The banded type is the most characteristic for the whole region. The most suggestive as to origin and interpretation are the quartzose rocks and the limestones, while the most deceptive and difficult are the granites and granite gneisses. Among these rocks there are numerous representatives of metamorphosed sediments of such character and relationship that their origin can not be mistaken. Almost as abundant are the igneous types, chiefly granites and their metamorphosed derivatives. Frequent small members are found whose origin is uncertain; but in almost every case similar varieties occur under conditions of relationship that usually leave no doubt as to their position and interpretation.

General structural features of the formation

Almost all of the various schists and banded gneisses, together with all of the quartzites, quartzose gneisses, graphitic schists, and limestones form an interbedded series. At all contacts between those members they are conformable. Most of them are thin beds. Several of the limestones are only 3 to 10 feet

thick and the largest yet seen need not be more than 30 feet. The quartzites and quartz schists are similar in their distribution but more common and occasionally more extensive. The banded gneisses and the more massive granitic gneisses are much more heavily developed and their thickness is not known.

The whole series is folded, crumpled, faulted, crushed, injected, intruded and intensely modified by recrystallization; but through it all they retain the fundamental association and essential character of an original sedimentary series. Nowhere is there a basal conglomerate. What is beneath is unknown.

Many of the occurrences of gneisses, a few of the schists, and all of the granites, diorites and gabbros are of igneous origin but all occur as intrusions or injections, as sills, dikes or bosses cutting the metamorphosed sedimentary members of the formation. Except in rare instances they are not even of sufficient constancy or prominence or areal extent or individuality to be given an independent designation. The most notable ones coming within such limitations are the " Yonkers gneiss," which appears to have been a great granite sill that can now be traced along the axis of the southern ridges for a distance of 15 miles; the " Storm King granite," which has a large development in Storm King and Crows Nest mountains and in the Breakneck ridge along the northern border of the Highlands; and the " Cortlandt series " of gabbro-diorite-granite rocks forming an immense boss on the east side of the Hudson river between Peekskill and the Croton valley. Even these, except the " Cortlandt series " are but large, intruded masses wholly within the gneiss formation. At the extreme southeast the " Harrison diorite " in its relations is somewhat similar to the Cortlandt series. Both cut through the gneisses into higher formations.

That this is the true relation between the igneous and sedimentary members is supported by the numerous eruptive contacts and inclusion phenomena. Of these no more convincing evidence need be sought than the occurrence of large angular masses of the banded gneisses and related sedimentary beds of various types wholly included within the granites along such marginal belts as at Constitution island, or on the west side of the Hudson near Fort Montgomery, or at the fresh workings of the Mohegan quarries a few miles east of Peekskill. At Constitution island only the more massive banded gneisses

occur, and therefore the association is somewhat obscure, although the relationship can be seen on the cliffs facing the main channel of the river. Below Fort Montgomery, on the contrary, great angular masses 20 to 50 feet in length, commonly of the quartzose and schist types and even the interbedded limestones themselves are included in the granite in the most strikingly clear-cut way. Nowhere are they better shown than along the cuts of the West Shore Railroad at that place. At the Mohegan quarries, the freshest and youngest and most massive type of granite of the Highland region breaks through not only the gneisses but also the uppermost of the crystalline formations of the district. In the quarry and the adjacent hillside, large inclusions of gneisses, quartzites and schists occur in even more complex development than in the other cases mentioned. Occasionally fragments of the later formations lie in proximity to those of the gneisses, all completely surrounded by true granite matrix.

With the sheetlike intrusions and smaller injections there is much less disturbance of this sort, and the eruptive nature of the contacts is chiefly evident in lenslike enlargements or dikelike development. On a large scale this is best developed with the " Yonkers gneiss," noted before, in the ridge extending from Mount Vernon through Scarsdale and White Plains. Similar relations on a large scale prevail in certain parts of the broad gneiss belt nearest the Hudson river from Spuyten Duyvil to the Croton valley. But in this case the intrusive is less easily distinguished from the inclosing series; it is itself gneissoid, and is more irregular in areal development, small intrusions of similar type are exceedingly numerous, too numerous and too limited in extent to be mapped or indicated separately. The lower limit is represented by the small pegmatite injections of a few feet or rods in length, lenslike bunches and stringers, sometimes making up a considerable portion of the formation, in some places surely connected with larger igneous masses, while in others they may have no true igneous origin. All are essentially but parts of the great basal gneiss, and the line separating those of sufficient prominence to be mapped as distinct members from those neglected or merged in the general color is wholly an arbitrary one.

Members of the basal gneiss

Systematic work from New York city to the northern borders of the Highlands on both sides of the Hudson river, especially in the Tarrytown and West Point quadrangles, reveals no evidence of any fundamental break or change in the gneiss formation. "The Fordham gneiss" of the Harlem quadrangle as indicated in the New York City Folio 83, United States Geological Survey, is not different in position or significance or general character from the same gneiss series of the Tarrytown quadrangle, with which it is continuous; and the writer sees no essential point of difference between these and the basal gneisses of the West Point quadrangle, from which they are separated by only a belt of later limestones and schists occupying the synclinal fold of the lower Croton valley. The same banded types and granitic facies, as well as the same relations to overlying formations, prevail throughout. But in the northern Highlands it appears that interbedded limestones and quartzites and schistose graphitic beds are common, whereas in the southern localities the limestones at least are not so frequently seen. Yet traces of such limestone beds are found as far south as the vicinity of the Jerome Park reservoir in the Harlem quadrangle. Whether they really do occur more frequently can not be determined because of the relative abundance of the overlying formations, which may normally cover the portions that contain these types. The whole area in the north, being eroded down to the gneiss floor, gives much better opportunity to discover the smaller and less resistant members. They are noted at several points and described by W. W. Mather in his *Geology of the First District* published in 1843. The best development of these interbedded limestones is along the Hudson river near Fort Montgomery and Highland Station, and near Garrison at Arden Point, and at McKeel's Corners northeast of Cold Spring. They have all been noted and mapped before, but have not been interpreted in this way.

No subdivision of the gneiss formation at present seems possible. There is no natural stratigraphic break. Because of the abundance and regularity of the igneous injections and the close folding and frequent faulting, it is not even clear as to the order of superposition of the constituent members. At a few places, in what seems to be an upper member, because of its connection with overlying formations, the banded black

and white gneiss most characteristic of the series passes gradu-
ally and normally into a mica quartz schist, and this in turn,
into a few feet of rather pure quartzite.   The best localities
are at Sparta, a mile below Ossining; on the Putnam division
of the New York Central Railroad, a mile south of Eastview;
in the small creek just south of Crugers Station; and on the
Harlem division of the New York Central Railroad about a
mile north of Chappaqua.   At every one of these points, where
the relation can be clearly made out, the quartzite is conformable
to the banded gneiss.   The outcrop at Sparta is by far the most
extensive one, but here it is repeated by folding and crumpling
to such extent as to make an estimate of thickness very unreli-
able.   It may be more than 100 feet thick there, but it does
not reach that amount at any other point.   This is the " Lowerre
quartzite " named after the locality from which it was first
described.

At each of these places, a coarsely crystalline limestone or
dolomite, equivalent to the " Inwood limestone " of Manhattan
island, lies next above, but not in sufficiently close proximity
or sufficiently simple relationship to determine whether or not
it is perfectly conformable.   Some other considerations [see
a later paragraph] indicate that this limestone may not be
strictly conformable, although it partakes of practically all of
the dynamic modifications that have affected the region.   It is
suggested that it may be conformable at one group of localities,
as is stated in United States Geological Survey Folio 83, and
not exhibit the same relation in other parts of the district,
indicating overlap conditions.   Such apparent conformity is
most prominent in the old quarry at Hastings on the northern
border of the Harlem quadrangle.

The Lowerre quartzite, therefore, because of its gradational
relation with the banded gneisses is, in all essential features,
only an upper quartzitic facies of the basal or Fordham gneiss
formation.   In comparison with the great formations of the area
it can scarcely claim a separate classification, but it is a dis-
tinguishable bed, the uppermost member, although not separate
in any fundamental sense.

It would seem consistent with the characters known for the
uppermost members and the succeeding formation (Inwood) to
consider the interbedded limestones and quartzites and graphitic
schists, as seen along the Hudson river from Fort Montgomery

to Garrison and in the creek valley from Cold Spring to and beyond McKeel Corners, as probably also belonging to the upper members of the gneiss formation. In this case the valley just referred to would represent an eroded syncline and the larger granite intrusions of the mountain ridges on both the northwest and southeast sides would represent eroded anticlines with granitic cores. Although this is a reasonable interpretation no further support to it is at hand, and no subdivision of the gneiss is yet feasible.

Overlying formations[1]

The formations that come in contact with the normal varieties of basal gneiss series are of six apparently separate types. Two are quartzites, two are limestones, and two are schistose to slaty in general character. The two quartzites have definite sedimentary contacts with the gneiss, though not alike. All of the others when in contact have been forced into that relation by faulting. Of the quartzites one is a rather inconstant bed varying from 0 to perhaps over 100 feet in thickness, rarely outcropping and in essential relation closely connected with the basal gneiss. This is the rock described as the "Lowerre quartzite" on a preceding page. The other is a very pure quartzite, of a thickness from 300 to 600 feet, and always with unconformable or faulted contact with the gneiss. It is not believed by the writer that these two formations can be equivalent. If this be granted, the other four formations may be divided into two groups, so that each has a definite and constant relation to one of these quartzites, and this together with allowance for certain structural features, to be described later, makes many of the seemingly abnormal occurrences of rock type in the region intelligible. These six formations are:

    5 A phyllite or slate (very thick "*Hudson River*")

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[1]It is recognized by the writer that this is a question of great complexity and considerable difference of opinion and interpretation. There is no attempt in this paper or at the present time to review these opinions or discuss their merits. Likewise it is appreciated that the general question of grouping of these overlying formations affects adjacent districts, with some of which the writer is not familiar.

    The reason for discussing local conditions affecting this problem at this time is the more clearly to present the meaning and influence of certain large structures that are not believed to have been given enough prominence and to indicate more fully the true position of the basal gneisses. There is no intention to attempt a broad application of this grouping; but it is believed to be worth while to present the evidence in its favor as it appears in the particular district under discussion.

    To W. W. Mather (1) and the late Prof. J. D. Dana (2) and Dr F. J. H. Merrill (3) belongs the chief credit for the descriptions, summaries and interpretations that have been published.

    1 Mather, W. W.   Geology of New York: Report on First District.   1843.
    2 Dana, J. D.   Limestone Belts of Westchester County, N. Y.   Am. Jour. Sci. XX, 1880.
    3 Merrill, F. J. H.   Geology of the Crystalline Rocks of Southeastern New York.   50th N. Y. State Mus. Rep't 1896.   Appendix A.

4 A fine grained blue and white banded limestone (1000 feet *Wappinger*)

3 A fine grained quartzite (300 to 600 feet, *Poughquag*)

2 A coarsely crystalline mica schist, pegmatitic (very thick *Manhattan*)

1 A coarsely crystalline limestone, tremolitic, micaceous, pegmatitic (200 to 800 feet, *Inwood*)

0 A thin schistose quartzite essentially part of the gneiss (1 to 100 feet, *Lowerre*)

Numbers 1 and 2 forming a group, are strictly conformable to each other, and so are nos. 3, 4 and 5. The two groups so far as the writer is aware, are not at any place in direct contact with each other although such relationship may obtain beneath the water level at the mouth of Peekskill creek.

This locality including Peekskill Creek valley and Sprout Brook valley are believed to exhibit features of the greatest significance. From the junction of the two streams about a mile northwest of Peekskill, the two valleys diverge toward the northeast. The lower 3 or 4 miles of each valley carries the formations that are considered by the writer typical of the two groups whose relationships are so obscure. Along the ridge between the two valleys passes a great fault which has allowed the block on the southeast of this line, i. e. the Peekskill Creek valley and adjacent territory, to drop much lower than the northwestern side on which Sprout brook is located. [See discussion of structural features] Therefore, in these two adjacent valleys, formations of very different type occur so near together that their differences must be considered fundamental. In Peekskill Creek valley the typical 3, 4, 5 group occurs—500 feet of quartzite, probably 1000 feet of limestone, and a great thickness of phyllite. This is, without the slightest doubt, the Poughquag quartzite-Wappinger limestone-Hudson River slate group. It is worthy of special note that even on this southern margin of the Highlands these formations have not lost any of their usual characteristics so well exhibited north of the Highlands. The contacts here are fault planes. The whole group is gradually cut out in passing northeastward, the higher beds disappearing first and the quartzite being traceable for at least 10 miles along this valley.

In Sprout Brook valley, only a mile across the ridge, limestone alone occurs. Because of its proximity to the limestone

of Peekskill creek this affords a striking contrast. It is coarsely crystalline whereas the other is fine; it is very impure with silicates and pegmatites, and has occasional dike intrusions and strong epidotic development whereas the other has none; there is no quartzite on either margin of this Sprout Brook limestone and none beneath it, as may be seen by following up the brook to the point where the limestone disappears, whereas the other has at least 500 feet of quartzite conformably beneath. For more than a mile this crystalline limestone occupies the valley for a width of at least ¼ mile. It is well developed for a distance of over 6 miles. It must be several hundred feet thick at the lowest estimate. Farther up the valley, where the limestone disappears, only gneisses of typical Highlands types remain. It is clear that the limestones of these two adjacent valleys can not be the same. The Sprout Brook representative is much the older. It can not by any interpretation be the equivalent of the Wappinger. But the question still remains as to its relationship to other known limestones. Several small interbedded limestones occur in the gneisses at points between this locality and the Hudson river at Garrison. Could this Sprout Brook limestone be an unusually large one of them? Its great thickness, the breadth of valley that it fills for several miles, its final disappearance entirely toward the northeast, and its nonappearance anywhere else in the region are considered insuperable objections to that view. On the other hand if this valley be considered a simple syncline pitching gently southwestward then the limestone becomes an overlying formation of the normal Inwood limestone relationships and character. This is the interpretation of the writer. The syncline is too closely folded and too shallow to have preserved any of the overlying Manhattan schist which it is believed belongs with it. If this is the correct identification then the Inwood limestone and the Manhattan schist are lower and older than the Poughquag quartzite, and therefore can not be correlated with the Wappinger limestone and Hudson River slates as has previously been done.
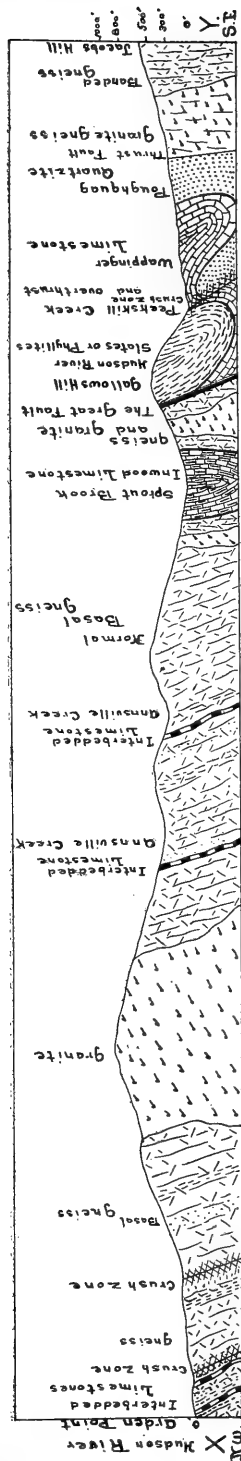
CROSS-SECTION FROM ARDEN POINT ON THE HUDSON RIVER SOUTHEASTERLY TO JACOBS HILL NEAR PEEKSKILL

Line X-Y on the outline map

Vertical scale magnified two times. Distance six miles

The section presents a generalization of the structural and stratigraphic relations of the region—especially the three types of limestone—i. e. the interbedded limestones of Annsville creek and the vicinity of Arden point, the coarsely crystalline limestone in direct contact with the gneiss at Sprout brook, and the fine grained limestone lying upon 500 feet of quartzite at Peekskill creek.

The intrusive nature of the granites and granite gneisses is indicated. The great Peekskill Valley fault on the line of this section cuts over Gallows hill. It is a normal fault. The others are thrust faults. Several crush zones also are crossed by the section, the principal ones being indicated above. No attempt is made to indicate the very numerous changes in character of the basal gneiss or the frequent occurrence of structures of minor importance.

In general for the whole Highlands region and southward, the lower group, nos. 1 and 2, Inwood and Manhattan, never give evidence of great unconformity with the gneiss. The formations are contorted in an exceedingly complex manner, are always thoroughly recrystallized, follow the general foldings of the lower gneiss and are abundantly injected especially by the pegmatites and basaltic or diabasic intrusions and rarely by granites in similar manner to the gneiss. But the group is not always in contact with the same members of the gneiss series. For example, only a few of the many outcrops of crystalline limestone exhibit a contact with the quartzite referred to as the Lowerre and which it is supposed to succeed. The contacts are quite as likely to be with the banded gneiss or massive granitic gneiss or even granite and schist. Of course, much of this may be due to flowage in connection with the close folding and metamorphism to which the whole series has been subjected. But this common observation together with the fact that the gneiss is much more complexly injected with igneous types and contains an amount of such matter greatly exceeding that found in the overlying group and also types not found in them at all, leads to the conclusion that there is not a perfect conformity with the basal gneiss. It probably represents an overlap type of sedimentary contact.

Number 3, and therefore the whole group 3, 4, 5, is always clearly unconformable on the gneiss where its true relation can be determined. It lies on the upturned and eroded edges of the folds of the basal gneisses. No part of this series is intruded or cut by igneous masses or injected with pegmatites or in any way complicated by the igneous associations so characteristic of the older formations, except by the Cortlandt series. That igneous mass, however, has such a distinct isolation from the other igneous types that it may readily be dealt with as an exception.

This upper group is sometimes not disturbed, as for example along some parts of the northern border of the Highlands, south of Johnsville village and Shenandoah, where the unconformity is beautifully shown and where it may be seen to have taken no part whatever in the metamorphic foldings of the gneiss. This upper group as developed along the northern margin just described is known to be of Cambro-Siluric age. Fossils are not plentiful but have been found at several localities; Cambric

types in the quartzite, both Cambric and Lower Siluric in the limestones and Lower Siluric in the slates. The quartzite is the true " Poughquag."

In Peekskill Creek valley and along the south margin of the Highlands, southwest of Tompkins Cove, the same relations prevail in every respect except that there is later faulting and close folding in this belt. The group, however, is not crumpled and contorted into the complexities prevalent in the lower formations. Only where it comes into contact with the Cortlandt intrusion does it become at all complex in structure or petrographic character.

For these reasons, together with the support given by the fault structure next to be described, but stripped of most of the details of local observational descriptions, it is the writer's opinion that there are two distinct groups of formations above the basal gneisses in the Highlands region. The older and more complex, wholly crystalline, at the base a limestone (Inwood) followed by a schist (Manhattan) both of Precambric age, occupies together with the gneisses almost the whole of the Highlands and the southward extension to New York city. The younger, a Cambro-Siluric series with a thick quartzite always at the base (Poughquag) followed by a limestone (Wappinger) and completed by a slate (Hudson River) forms a continuous border along the north of the Highlands and occurs in only an occasional fault valley along the southern border, notably Peekskill Creek valley, its extension southward, and a few adjacent localities.

Structural features of the region

Folding is evident everywhere. The gneisses almost always stand at very steep angles, vertical or nearly so, and sometimes are overturned, all evidently the eroded edges of large folds. Where proximity to or contact with overlying formations aids in forming a conception of the correct superposition, it appears that the overturning is chiefly toward the northwest.

The general strike of all the major folds is northeast and southwest. But in the vicinity of the Cortlandt igneous mass the strike is nearly east and west. Besides there are occasional cross-foldings on large enough scale to radically change the strike for considerable distances. Minor crumplings indicate a common tendency of this sort. A general cross-folding effect

as one follows the beds northeastward along the strike is an
occasional offset of the whole ridge to the northwest. This pro-
duces embayments in the gneiss ridges occupied by later forma-
tions, such as those along the eastern margin of the principal
southern ridge at Eastview and Pleasantville ; or it produces pitching
anticlines appearing in the areal geology as lenselike outcrops of
gneiss, such as that east of Sherman Park or those between
Ossining and the Croton valley; or it changes the courses of
streams, as at the great bend in the Hudson river from Iona
island to Roye hook.

Faults are probably as numerous and complex as the folds,
but much more difficult to detect. Estimates of the extent of
displacement are valueless except where upper formations are
involved in the movements. It is clear, however, that the greater
faults follow the general strikes of the folds. Some of the
fault zones are so nicely healed by recrystallization that they
are not at all apparent by the commoner criteria, and often
these zones are not lines of present weakness. But where a
limestone formation 500 to 800 feet thick is sheared down to
less than 100, or entirely out, as sometimes happens, there is
no mistaking the essential fault nature of the displacement.
This is characteristic of the older movements. Where the two
walls are not so unlike, most of them no doubt escape observa-
tion. They occur not only in the valleys but across the higher
ridges as well. There would appear to be some cross faulting
of this early period also but for this the evidence is not so clear.

A later set of faults is more easily followed. They also are
chiefly in line with the northeast and southwest structure, with
smaller cross faults, but they have developed prominent shat-
tered zones, slickensides and weaknesses that make detection
easier. The displacements noted in the cross faults of this set
are not in any case great and their strike does not vary greatly
from east and west in the clearest cases.

The principal northeast and southwest faults of this later set,
however, occasionally exhibit a great throw. Among them are
two that will serve the present purpose and that deserve special
attention because of their bearing on other issues. One of these,
not in any strict sense a single line, but rather a succession
of them, follows closely the northern border of the Highlands
ranges, each separate fault line striking out toward the north-
east into the bounding slates and its place taken by another

nearer the margin. One of these follows closely the northern base of Storm King mountain and Breakneck ridge. Where it is best exposed, a mile southwest of Cornwall Station, the walls show a fault plane dipping steeply to the southeast with the granites of Storm King overriding the Hudson River slates. This overthrust, therefore, represents a displacement of probably 2000 feet and perhaps more. The overthrust tendency from the southeast is apparent at many other places, and it serves to create some most abnormal relations throughout the Cambro-Siluric area lying to the north where overthrusts of great complication are the rule, such as that at New Hamburg or at Cronomer hill, north of Newburgh.

The other notable fault of even greater significance occurs on the south side of the Highlands proper and the escarpment along this line marks a physiographic and stratigraphic boundary for many miles. This fault line follows the west side of Peekskill creek to the Hudson river, crosses to Tompkins Cove, and then passes to the southwestward across the New York State boundary into New Jersey. It sharply limits the Highlands Precambric and its displacement established an escarpment against which the Triassic sediments were laid down and which yet marks their interior limits. Present conditions of the strata preserved along this line indicate two separate movements: first, block faulting and tilting by which the south wall was dropped probably 2000 feet or more, carrying down into the trough thus formed all the overlying Cambro-Siluric formations that at that time covered the Highlands; later a thrust from southeast closely folding the sediments entrapped in this trough and in places thrusting the gneisses upon them. The net result is a preservation of representatives of the later group of formations (Cambro-Siluric) along this fault line. This is especially successful on the margin of the down faulted block, so that, in Peekskill Creek valley and the next small valley to the southeast, and from Tompkins Cove southwestward for some distance, these formations may be seen. But because of the somewhat similar succession of members and character, and because of the oversight of this profound structural break, the identification of the formations of this district has been confused with the older group. It is the writer's belief that this allowance made for the occurrence of the seemingly abnormal strata in the southern Highlands permits reasonable explanations for all occurrences

and is a considerable support for the theory of two separate sedimentary groups. These larger faults are believed to be chiefly responsible for the sudden disappearance of the Manhattan schist.

If there be, as seems reasonable, a north and south fault in the Hudson river also from Peekskill southward, it will be noted that such a line would intersect the one just described in the Peekskill area. Most suggestive is the occurrence of the Cortlandt igneous intrusion just at the acute angle of the depressed block thus outlined. On every margin of the Cortlandt area are evidences of faulting, fault breccias, shear zones, clear-cut faults, great inclusions, and abrupt transitions. That this igneous outbreak is genetically connected with the development of excessive weakness at this point by the block and thrust faulting of the district appears to give an explanation of its limited areal distribution and its occurrence at a time not marked by igneous activity in other unrelated areas.

Age of the basal gneisses

The age and exact correlation of this lowest formation is unknown. It has all the physical character of the " Grenville series " of the Adirondacks and Canada as described by geologists in those districts and as seen by the writer at a few points in the Adirondacks. In view of the agreement in petrographic character and general stratigraphic features it is believed to be a part of the " Grenville series." It is surely not Archean, in the present meaning of that term as now applied in the Great Lakes region of the United States and Canada.

The relative age of this formation is more clear. It is the oldest of the immediate region under discussion. It is wholly Precambric. It is, in the writer's opinion, separated from the lowest representatives of the Cambric shown above by one overlap unconformity probably of no very great time break, a group of sediments (Inwood limestone and Manhattan schist) of great thickness, and an unconformity marked by mountain folding and erosion. Therefore it is immensely older than the Cambric and its stratigraphic position under this conception of the relations between the overlying formations may be tabulated as follows:

Tabulation of the formations

	SEDIMENTARY SERIES	IGNEOUS SERIES
Lower Siluric	Unconformity Hudson River slates Wappinger limestone	Cortlandt series Diorites Gabbros Peekskill granite
Cambric	Poughquag quartzite	Harrison diorite
	Unconformity	Pegmatites
	Manhattan schist	Basaltic and diabasic **or** dioritic intrusions
	Inwood limestone	Granite and other dikes
Precambric	Overlap unconformity	

	Grenville series
	    Lowerre quartzite, Ford-
	    ham gneiss, and the
	    various basal gneisses of
	    the Highlands, including
	    interbedded limestones,
	    quartzitic and graphitic
	    schists
		Storm King granite
		Yonkers gneiss and other
		    granites, diorites, and cor-
		    responding gneisses

Relative age of the igneous intrusions

All igneous rocks of this area are younger than the sedimentary members of the basal gneiss. But there are great differences among them. Some of the intruded stringers and sills may date back to the early history of these sediments since they partake of all the metamorphic changes that characterize these ancient strata including recrystallization and flowage. Representatives of such early types are mostly granite gneisses and are everywhere confined to the basal gneiss formation. Many of them are very similar to the coarser metamorphosed sediments and lead to the greatest uncertainties of interpretation. Others, such as the pegmatite streaks and some of the basic intrusions of original diabasic character, belong to the period of most extensive metamorphic activity and penetrate also the next overlying limestone (Inwood) and the schist (Manhattan). But they do not affect anything higher. Therefore

they are of later age than the gneiss proper, although still Precambric according to the writer's interpretation of the series.   The Harrison diorite appears to belong to this general position or perhaps still later.   Last of all is the Cortlandt series of gabbros and diorites cutting every formation in the district and including fragments of them so that this last must be Post-Lower Siluric in age.

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New York State Museum
JOHN M. CLARKE, Director
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5	56, v. 1	10	57, v. 1	19	57, v. 1, pt 2	7	56, v. 4
6	57, v. 1	Z 3	53, v. 1	20	" v. 1 "	8	57, v. 2
Eg 5, 6	48, v. 1	4	54, v. 1	21	" v. 1 "	9	" v. 2
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10	" v. 3	10	57, v. 1	5	55, v. 1	2	40, v. 3
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M 2	" v. 1	4–6	52, v. 1	7	57, v. 2	5, 6	57, v. 3
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1 Beecher, C. E. & Clarke, J. M. Development of Some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. *$1.*

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3 Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co. N. Y. 128p. 9pl. Oct. 1900. *80c.*

4 Peck, C. H. N. Y. Edible Fungi, 1895–99. 106p. 25pl. Nov. 1900. *75c.* This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.

5 Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. *$1.50, cloth.*

6 Clarke, J. M. Naples Fauna in Western New York. 268p. 26pl. map. *$2, cloth.*

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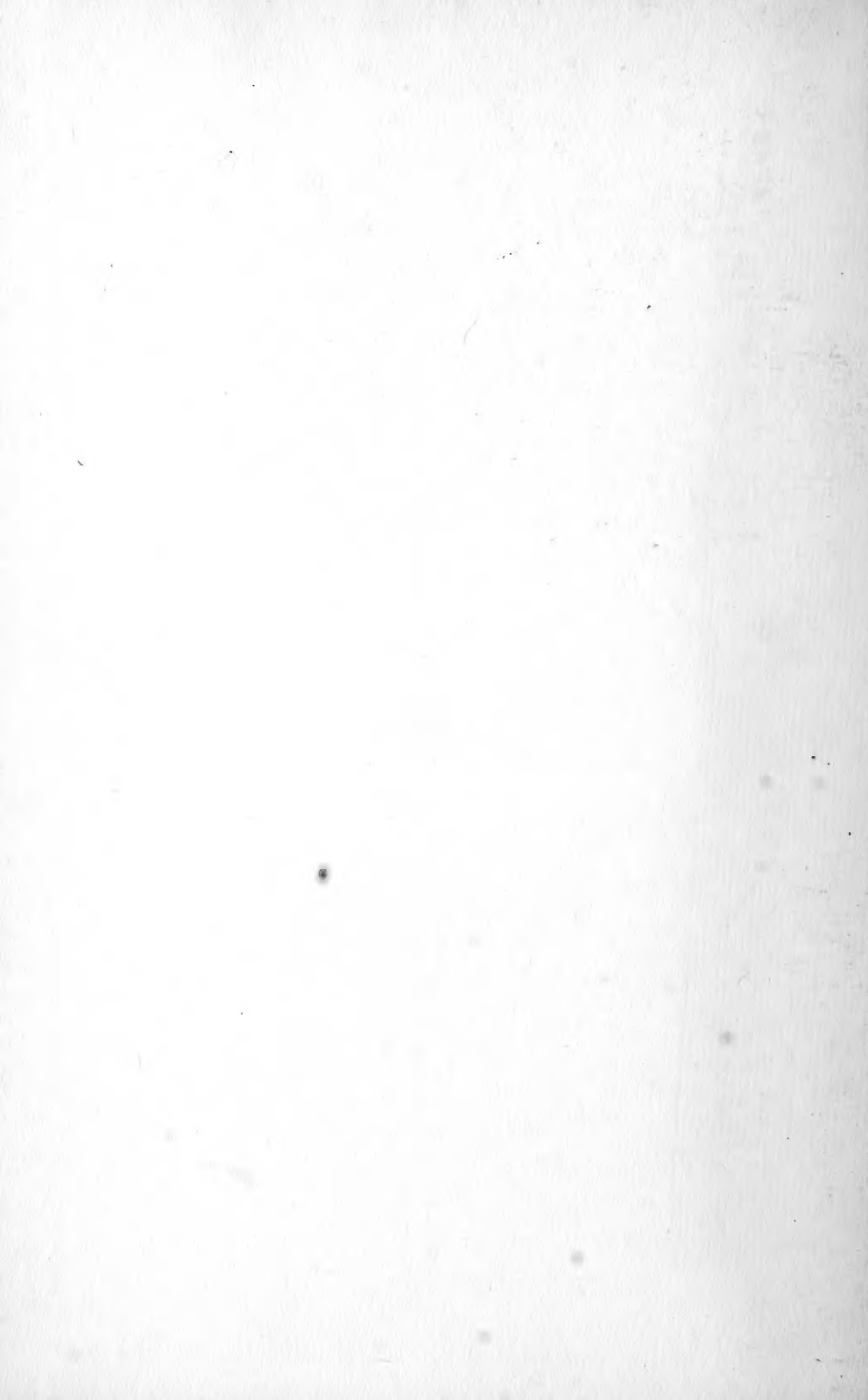*Watkins-Elmira quadrangles. Mus. bul. 81. 1905. 20c.
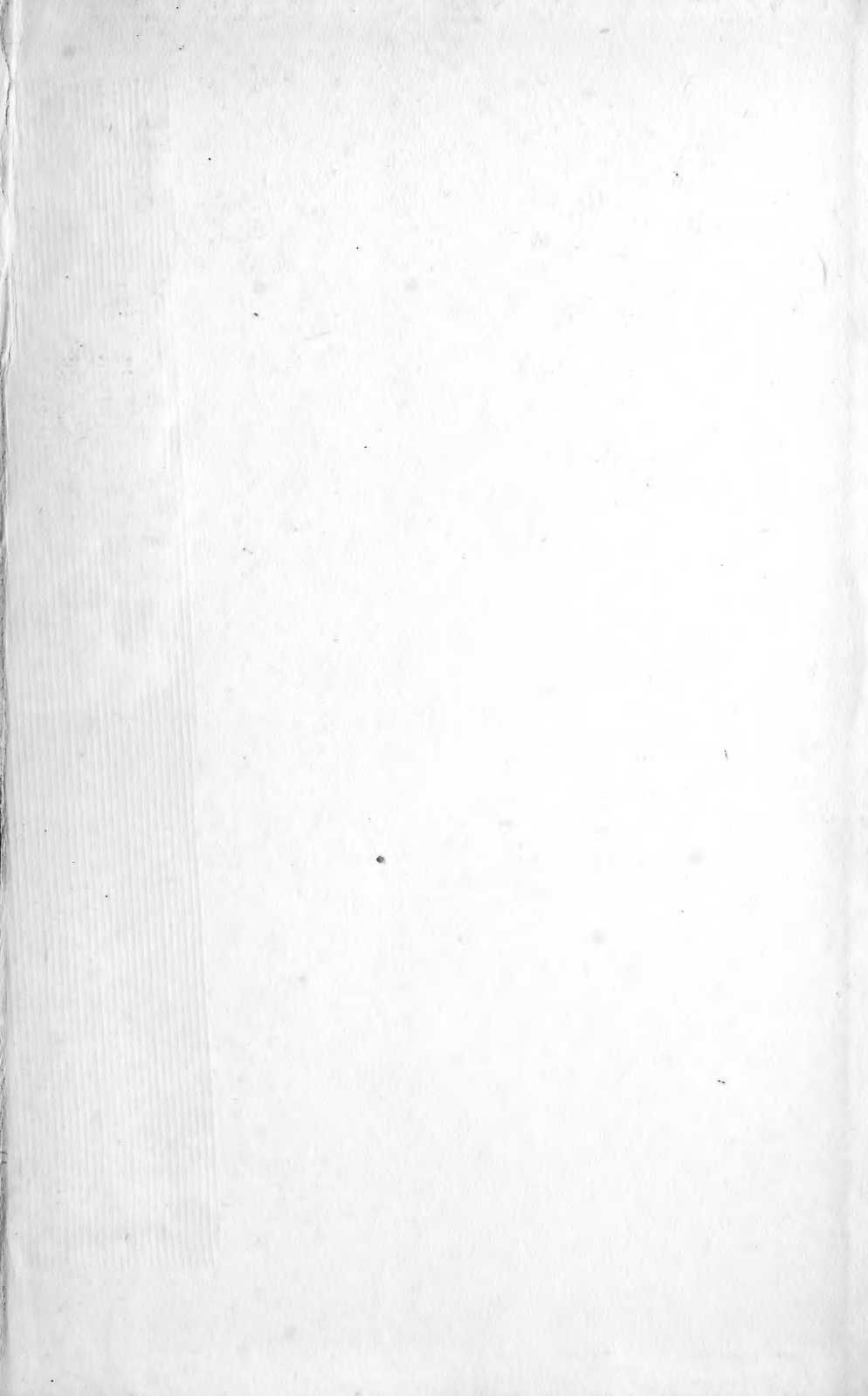*Tully quadrangle. Mus. bul. 82. 1905. 10c.
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